going on from a predominately timber-based economy to a more diversified timber, recreation and agricultural-based socio-economic system. In the upper peninsula, changes have been more gradual, but a trend from a timber and mineral-based economy to a timber and recreation-based socio-economic system can be perceived.

The State will never again see vast forest acreages similar to those present in the circa 1800 period. Yet inventory data indicate that the forests of the state have been on a steady path towards recovery from the over-exploitation and fire devastation that took place at the end of the 19th Century and the beginning of the 20th Century. This indicates that timber and other natural resource-based industries will remain significant, contributing segments of the social and economic fabric of the state for the foreseeable future.

3 - CURRENT FOREST CONDITIONS, USES AND TRENDS

The present forests of the State are a legacy of the natural vegetative succession pathways and post-settlement practices. The landscape is mostly composed of second growth forests that have been heavily influenced by a variety of human-induced disturbances. This started with harvesting of white and red pine and many other species, followed by large-scale catastrophic wildfires fueled by the resulting slash, and then moving to a period of near total exclusion of fire from the landscape. Few of these secondary forests possess the structural characteristics of the circa 1800 forests. With the exception of some rare community types, the state's present population levels, ownership patterns, and social and cultural values preclude the restoration of our remaining forests to circa 1800 conditions. Such restoration would necessitate dramatic changes in timber production, wildlife management and many forms of recreation.

The re-growth of the forest resource has presented us with more choices for management of these resources, including timber production, many forms of recreation, the provision of terrestrial and aquatic wildlife habitat, and the provision of other ecosystem services (such as maintenance of water and air quality, soil conservation, and carbon sequestration). However, this has also made management of these resources much more contentious, as different interests compete to use the State's forest resources for increasingly conflicting purposes. The capacity of forest resources to provide for these uses in a sustainable manner is finite. Since uses are not perfectly compatible, the forest cannot provide maximum use for all demands. Provision of one use is often constrained by demands for other competing uses for the same resource, and the capacity of the forest base to provide for these competing uses is infinite in its variability. Thus, the annual capacity of forest resources must be framed in terms of balancing competing uses. Emphasis should be on the means to enable uses to be compatible with other uses, with the recognition that at any one site one value or use may predominate over others.

In order to effectively formulate appropriate management strategies in this environment, it is helpful to have an understanding of the changes in forest composition and structure that has occurred over the past 150 years and the ecological consequences of those changes. According to Noss (1999), it is difficult to develop a strategy to manage forests in a sustainable manner without identifying the specific structural and functional changes that have led to current conditions. An understanding of how historical events have led to current forest conditions, coupled with an analysis of current inventory data and current uses of the forest resource base can provide the foundation for present strategies and future structural changes that will support sustainable forest management.

This section describes the current condition of DNR forest resources and the current capacity of its uses. It will also explore the ecological consequences of these uses in terms of changes in

composition and structure. The analysis of forest resources in this statewide-scope forest management plan and in each of the ecoregional management plans is based on an ecological classification system. Hierarchical systems use ecological factors for classifying land at varying geographical scales ranging from global to local land units (Table 3.1). The primary purpose for delineating ecological units is to identify land and water resources at different levels of resolution that have similar characteristics thereby implying similar management potential. Depending on scale, ecological units are designed to exhibit similar patterns in: (1) potential natural communities; (2) soils; (3) hydrologic function; (4) landform and topography; (5) lithology; (6) climate; and (7) natural processes such as nutrient cycling, productivity, succession, and natural disturbance regimes associated with flooding, wind, or fire (Cleland et al. 1997).

Michigan has four ecoregions that are widely recognized (Figure 2.1). The four ecoregions are geographically based systems for organizing information about ecosystems and ecosystem responses to management. Each ecoregion provides a theoretical basis for science-based planning and adaptive management. The use of ecoregions often improves the accuracy of ecosystem models, projections of change, and predictions of desired future conditions. Ecological classifications in Michigan divide the state into progressively smaller ecological units, and watersheds can also be considered in this context. Within each ecoregion there are distinct identifiable subsections and watersheds that allow for a more strategic, multi-forest, multi-agency/ownership analysis and assessment of resources. Watershed analyses of the health of aquatic resources are parallel analyses that address aquatic community and habitat linkages across different terrestrial landscape attributes as well as provide the conduit and connection with the Great Lakes.

Table 3.1. Hierarchy of Ecological Units.
(Cleland et al., 1997)

Planning and analysis scale	***Ecological Units***	***Purpose, objectives, and general use***
Ecoregion Global Continental Regional	Domain Division Province	Broad applicability for modeling and sampling. Strategic planning and assessment. International planning.
Subregion	Section Subsection	Strategic, multiforest, statewide, and multiagency analysis and assessment
Landscape	Landtype association	Forest or area wide planning, and watershed analysis.
Land Unit	Landtype Landtype phase	Project and management area planning and analysis
Hierarchy can be expanded by user to smaller geographical areas and more detailed ecological units if needed.		Very detailed project planning

This state forest management plan provides an analysis of the forest resource base on statewide and ecoregional scales. The ecoregional management plans provide an analysis of the forest resource on a subregional scales. The following sections begin an analysis of the condition of forest resources from both a state wide perspective and also a more narrow focus upon DNR-owned forestland. It addresses the use of the resource base for timber production, discusses forest health conditions, and concludes with a discussion of wildlife, fisheries and human uses of forest resources.

3.1 - General Land Cover and Forest Resource Base

3.1.1 - State-wide Forest Conditions and Trends

Five statewide forest inventories were conducted by the U.S. Forest Service during the last century, and data from the latest was available in 2005. These inventories indicate that forest acreage has remained relatively stable since the 1950s. The only exception to this was a slight decrease between 1966 and 1980, followed by an expansion between 1980 and 1993 (Figure 3.1). Losses or conversions out of forestland between 1980 and 1993 were compensated for by other lands being converted into forestland. The predominant land type converting into forestland was agricultural. In contrast to the stable forest acreage, total standing timber volumes have almost tripled since the middle of the last century, reflecting a maturing forest.

The expanding volume also indicates that more growth has been continuously added to the forest than what has been removed or died through natural causes as evidenced by annual growth that has steadily increased over the past 50 years (Figure 3.2). Michigan's surplus growing stock (annual net growth less harvests) is among the largest in the nation, with forests currently growing

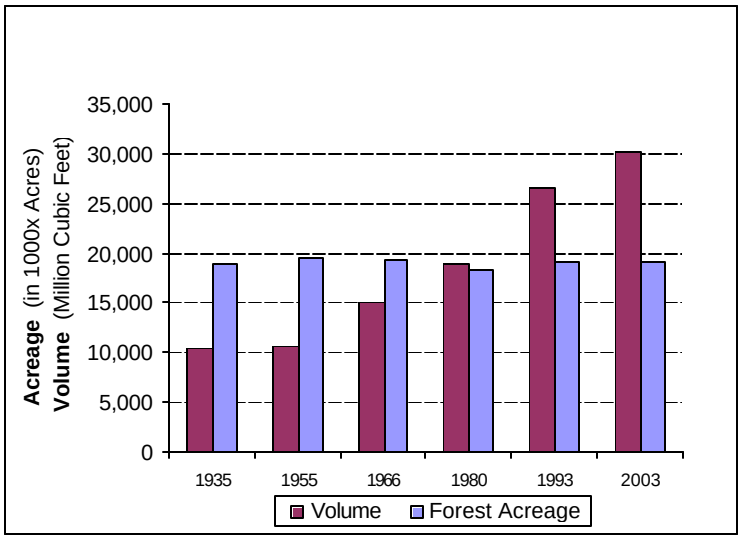

Figure 3.1. Acreage and Volume of Michigan Forest from 1935-2003. (U.S. Forest Service, 2003)

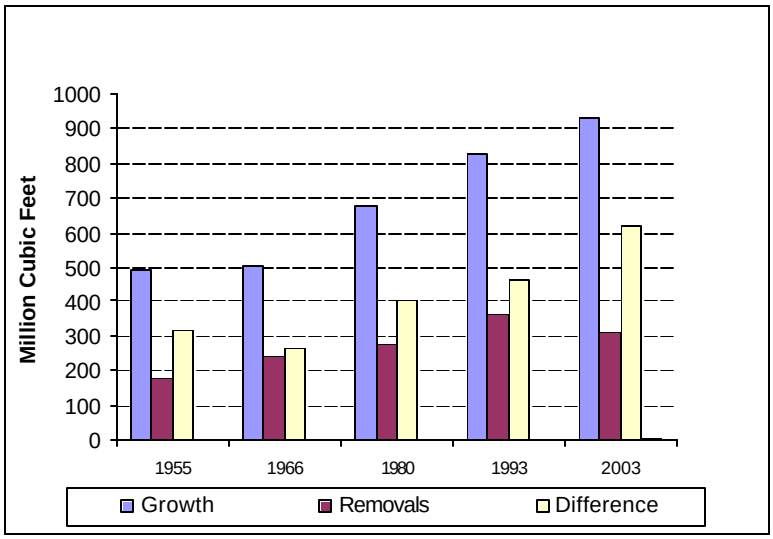

Figure 3.2. Volume of Michigan Timber Growth and Removals for 1955 – 2003. (U.S. Forest Service, 2003)

almost 3 times more wood than is being harvested each year, and this trend is expected to continue. The majority of annual net growth occurred in the hard and soft maple, white and red pine, and cottonwood and aspen forest types. However, this growth does not imply that the state is becoming increasingly covered by large contiguous tracts of forest land. Rather, as the landscape has been slowly restored and as forests have matured, it has simultaneously become increasingly fragmented by roads and other development. This has had negative impacts upon interior forest wildlife species and conversely had a positive impact upon wildlife species adapted to open and edge habitats.

On a statewide basis, Figures 3.3 and 3.4 show an estimate of the extent of circa 2000 community and forest types. At present, the largest forest type is northern hardwoods (5 million acres), followed by aspen/birch (3.2 million acres), mixed oak/hickory (2.6 million acres), aggregate pine communities (2.4 million acres), cedar and mixed conifer swamps (2.1 million acres), and southern (or central) hardwoods (1.5 million acres).

With an understanding that classification systems tend to simplify forest types (which in reality are often quite heterogeneous in composition), several general trends are apparent when comparing the relative areas of the circa 1800 forests to the area of current forestland (Table 3.2). The aspen/birch, black ash, red pine, jack pine, mixed oak/hickory and cedar forest types now cover a much larger proportion of the landscape than their circa-1800 extent. Particularly, the aspen/birch type has increased in acreage by almost 1,000%, whereas the savanna and barrens communities, hemlock, southern hardwoods, mixed conifer swamp, mixed white pine types, northern hardwoods and spruce/fir types now cover a smaller portion of the landscape than their historical extent. Savanna and barren communities, and hemlock types are almost completely absent from the landscape.

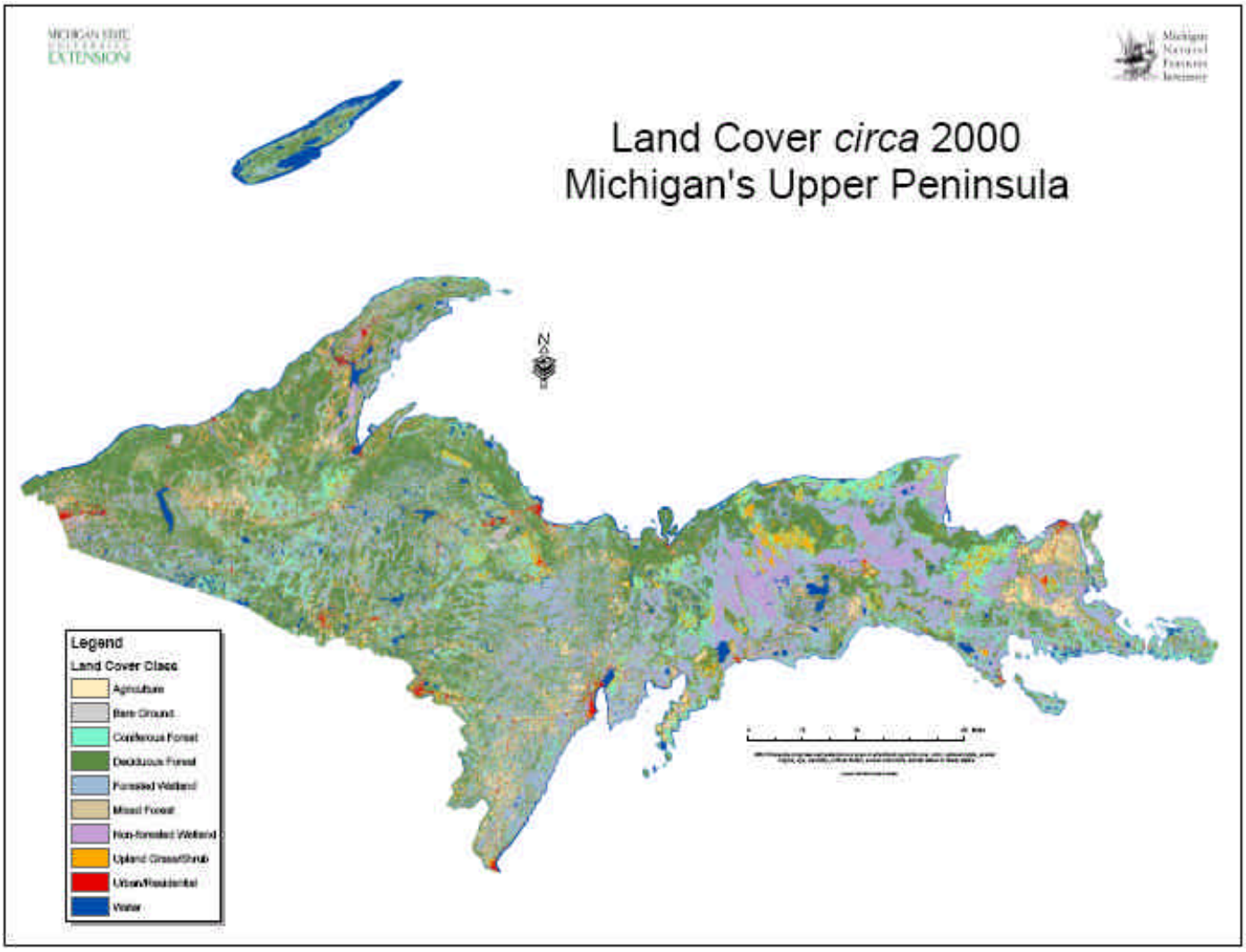

Figure 3.3. Land Cover of Michigan circa 2000.
(Michigan DNR, 2001)

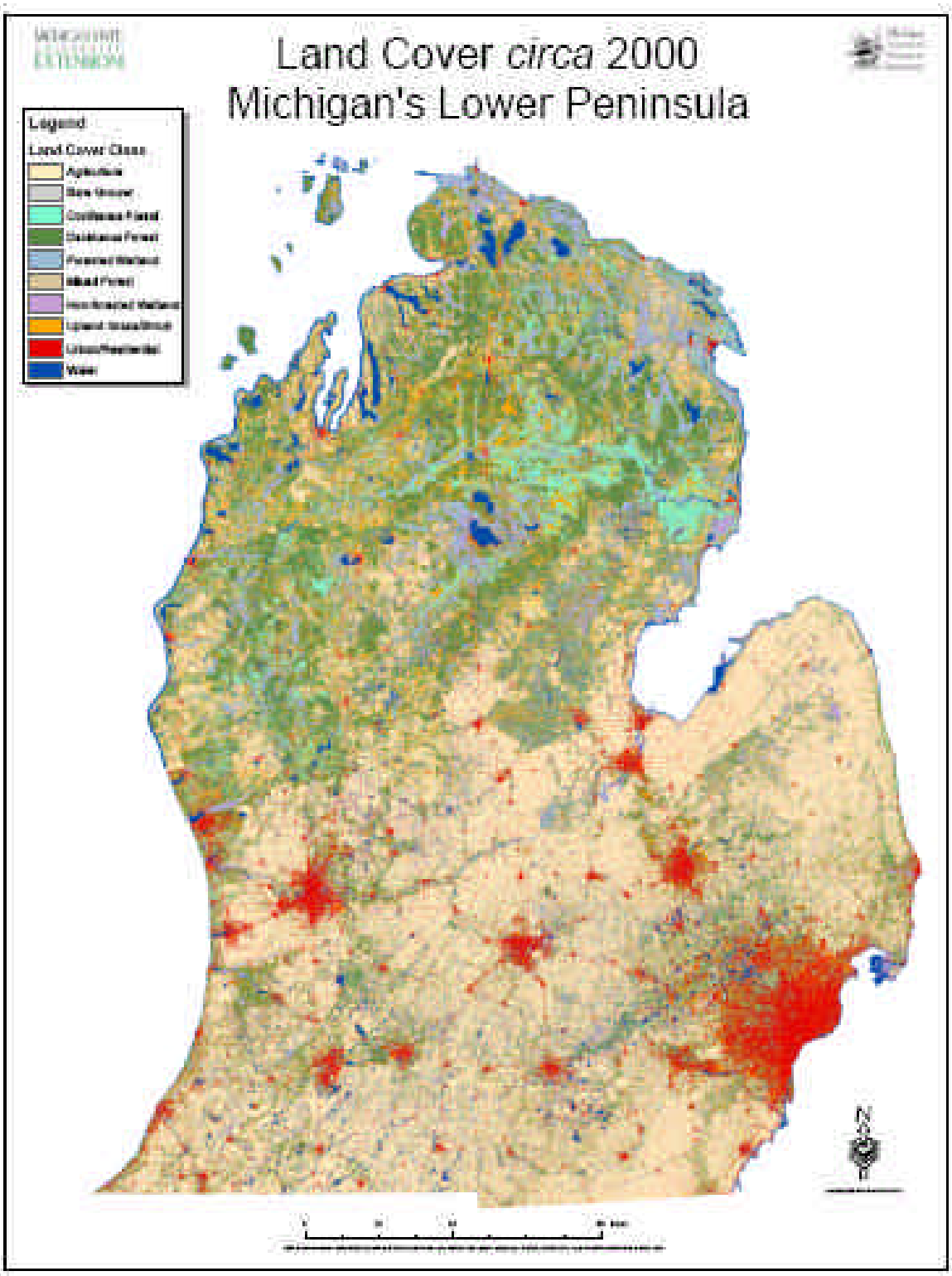

Figure 3.3 (Continued). Land Cover of Michigan circa 2000.
(Michigan DNR, 2001)

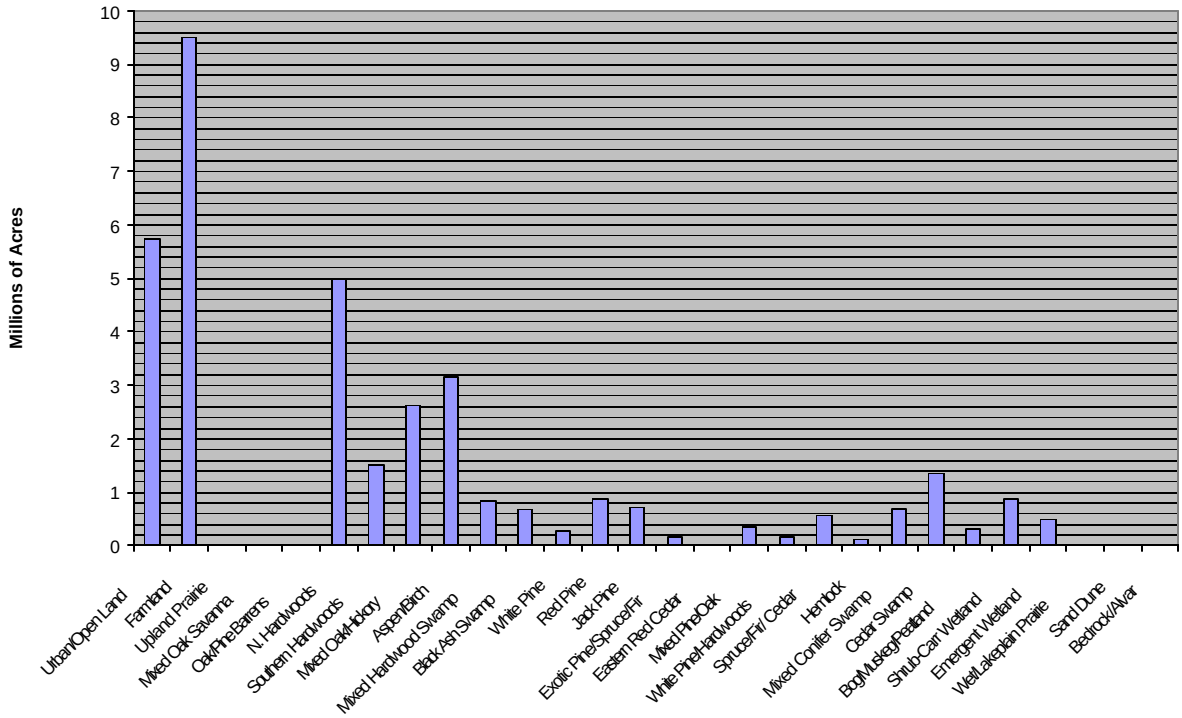

Figure 3.4. Acreage of circa 2000 Landscape Communities.
(U.S. Forest Service, 2003 and MDNR, 2001)

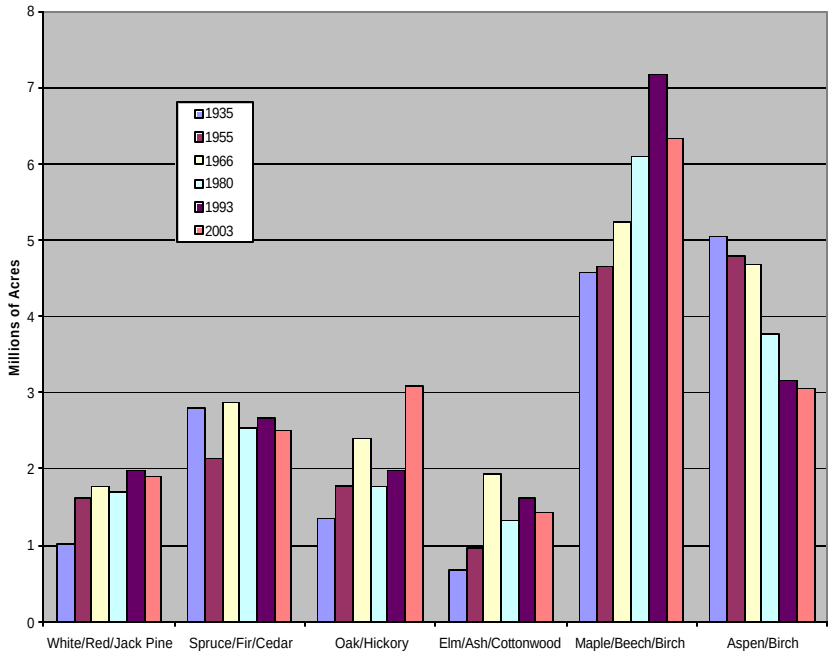

Figure 3.5. Area of commercial timberland by forest type group for 1935-2003.
(U.S. Forest Service, 2003)

The estimated extent of commercial timberland has changed significantly from 1935 through 2003 for forest type groups in Figure 3.5, from which some qualitative (but not quantitative) trends can be determined. A detailed discussion of trends for different forest types follows.

The extent of the aspen/birch forest type has increased from less than 1 percent to over 16 percent of the forested landscape (Table 3.2). It is important to note that this comparison concerns larger, stand-level aspen communities. Aspen was historically a minor component of many circa 1800 forest communities and is likely under-represented in the reconstructed maps of the pre-settlement landscape. Regardless, the large increase in acreage can be attributed to the extensive areas of the state that repeatedly burned and where secondary succession of these two seral species occurred in the late 19th and early 20th centuries. Growth of aspen on a state-wide basis is estimated to be almost twice that of removals (Table 3.3). However, it is significant that mortality of aspen exceeds that of removals by a ratio of 1.5:1, suggesting that a large volume of aspen is not being harvested and is likely senescent in mixed stands that are succeeding to other forest types. The growth of birch is estimated to be over 1.5 times that of mortality and removals, but estimated birch mortality exceeds removals by a factor of 1.5 to 1.

To a large degree, contemporary management practices have perpetuated the aspen community type. However, the aspen/birch type has been in decline since 1935

Table 3.2. Change in acreage of forestland from circa 1800 to circa 2000.
(U.S. Forest Service, 2003, DNR, 2001 and Michigan Natural Features Inventory, 1998)

Michigan Forestland	Circa 2000 Acreage	Circa 2000 Percent	Circa 1800 Acreage	Circa 1800 Percent	Change in Acres	Change in Percent
Aspen/Birch	3,163,200	16.5	292,266	0.8	2,870,934	982.3
Black Ash Swamp	680,700	3.6	280,705	0.8	399,995	142.5
Cedar Swamp	1,351,700	7.1	1,254,055	3.6	97,645	7.8
Eastern Red Cedar	11,500	0.1	0	0.0	11,500	0.1
Exotic Pine/Spruce/Fir	178,600	0.9	0	0.0	178,600	0.9
Hemlock	118,800	0.6	4,714,602	13.5	-4,595,802	-97.5
Jack Pine	715,300	3.7	596,836	1.7	118,464	19.8
Mixed Conifer Swamp	701,200	3.7	4,290,553	12.3	-3,589,353	-83.7
Mixed Hardwood Swamp	834,900	4.4	1,421,462	4.1	-586,562	-41.3
Mixed Oak Savanna	1,500	0.0	1,061,564	3.0	-1,060,064	-99.9
Mixed Oak/Hickory	2,612,500	13.7	2,306,373	6.6	306,127	13.3
Mixed Pine/Oak	352,700	1.8	543,562	1.6	-190,862	-35.1
N. Hardwoods	4,971,900	26.0	7,503,633	21.4	-2,531,733	-33.7
Oak/Pine Barrens	11,400	0.1	1,101,424	3.1	-1,090,024	-99.0
Red Pine	886,000	4.6	70,889	0.2	815,111	1149.8
Red/Jack Pine	0	0.0	515,819	1.5	-515,819	-100.0
S. Hardwoods	1,520,400	8.0	5,845,677	16.7	-4,325,277	-74.0
Spruce/Fir/Cedar	557,700	2.9	823,253	2.4	-265,553	-32.3
White Pine	278,600	1.5	69,141	0.2	209,459	302.9
White Pine/Mixed Hrdwoods	164,500	0.9	1,185,681	3.4	-1,021,181	-86.1
White/Red Pine	0	0.0	1,132,097	3.2	-1,132,097	-100.0
Totals	19,113,100	100	35,009,592	100	15,896,492	-45.4

Table 3.3. Volume of growth, mortality and removals by forest type in Michigan (in cubic feet). (U. S. Forest Service, 2003)

Forest Type	Total Growth	Total Mortality	Total Removals	Total Mortality & Removals	Growth to Total Mort & Remvl Ratio	Growth to Mortality Ratio	Growth to Removal Ratio	Mortality to Removal Ratio
Aspen	99,756,474	33,119,071	22,667,116	55,786,187	1.8	3.0	4.4	1.5
Balsam Fir	12,789,291	3,698,342	2,494,154	6,192,496	2.1	3.5	5.1	1.5
Balsam Poplar	9,746,658	5,292,337	5,006,467	10,298,804	0.9	1.8	1.9	1.1
Birch	11,426,789	2,818,521	4,913,286	7,731,807	1.5	4.1	2.3	0.6
Black Spruce	17,645,081	4,929,772	2,069,219	6,998,991	2.5	3.6	8.5	2.4
Cottonwood/Willow	2,295,896							
Eastern White Pine	18,665,813	6,476,089	4,980,261	11,456,350	1.6	2.9	3.7	1.3
Jack pine	15,406,155	5,779,303	7,967,251	13,746,554	1.1	2.7	1.9	0.7
Lowland Hdwoods	51,268,434	20,960,373	11,759,335	32,719,708	1.6	2.4	4.4	1.8
Non stocked	1,694,663	2,527,374	6,582,457	9,109,831	0.2	0.7	0.3	0.4
N. Hardwoods	349,064,267	73,382,939	116,572,474	189,955,413	1.8	4.8	3.0	0.6
N. White Cedar	63,088,460	18,590,143	9,549,154	28,139,297	2.2	3.4	6.6	1.9
Oak	105,749,277	25,323,975	39,947,589	65,271,564	1.6	4.2	2.6	0.6
Other	50,809,500	11,505,918	50,202,281	61,708,199	0.8	4.4	1.0	0.2
Other softwoods	14,111,630	1,942,382	1,719,186	3,661,568	3.9	7.3	8.2	1.1
Red Pine	91,839,384	8,534,236	20,962,303	29,496,539	3.1	10.8	4.4	0.4
Tamarack	6,308,366	1,178,273	1,845,495	3,023,768	2.1	5.4	3.4	0.6
White Spruce	8,476,133	1,563,594	1,504,140	3,067,734	2.8	5.4	5.6	1.0
Total	930,142,271	227,622,642	310,742,168	538,364,810	1.7	4.1	3.0	0.73

Note: Sampling error estimate of some data is greater than 50%.

(although the decline became much less dramatic in the 1990s), again reflecting natural succession to more diverse late- successional community types (Figure 3.5). This modern decline of seral aspen/birch forests has major consequences for hunting interests that have become accustomed to high populations of game species that are adapted to and have thrived in this habitat, including grouse, woodcock and white-tailed deer. If the proportion of aspen/birch forest continues to decline, it is probable that populations of these game species will also decline. This also has significant ramifications for the timber industry which currently relies upon aspen as a major source of pulpwood.

The general ascending trend of the Maple/Beech/Birch group and the decline in aspen/birch may possibly be attributed to its succession to shade tolerant northern hardwoods (Figure 3.5). When compared to the circa 1800 landscape, mesic northern hardwoods now cover 2.5 million fewer acres (a 34% decline), but they have increased from 21% to 26% of the relative forest cover in the landscape and continue to slowly re-occupy areas of their historic range (Table 3.2). Growth is almost twice that of natural mortality and removals, and removals well exceed mortality (Table 3.3).

A mere 0.4% of mesic northern hardwoods in Michigan remain in circa 1800 condition (with a highly diverse structure and species composition), with 59 documented occurrences. Of these, only 8 occurrences totaling about 56,000 acres are high quality representations of this cover type (Cohen 2000).

Since circa 1800, the acreage of mixed oak/hickory forests has increased by 300,000 acres (13%) and the relative area has doubled from 6.5% to 13.5% of the forested landscape (Table 3.2). This trend is also a legacy of turn of the century forest fires, to which the regeneration of oak is adapted. The ascending trend of the dry-mesic oak/hickory forest type may also be attributed to the general warming of the climate since the 1800s. Growth of oak is estimated to exceed that of mortality and removals by a ratio of 1.6:1, and removals well exceed natural mortality (Table 3.3).

Since circa 1800, mixed hardwood swamps have decreased by 586,000 acres (41%) to 835,000 acres in overall area, but this loss has been partially offset by an increase in black ash swamps which increased by over 140% to 681,000 acres (Table 3.2). The acreage of lowland hardwoods has been on a general upward trend until the 1960s, with a slight decrease in acreage since that time, possibly attributed to increased pressure from development (Figure 3.4). Growth exceeds losses by mortality and removals by a ratio of 1.6:1. However, losses from mortality are almost twice that of removals (Table 3.3). As discussed further in the section on forest health, disease and pests have impacted the composition of lowland hardwood forests. American elm (*Ulmus americana*) was virtually eliminated by Dutch elm disease as a dominant overstory tree in many floodplain forests. The invasion of the emerald ash borer (*Agrilus planipennis*) threatens to further alter the species composition and structure of these forests.

The hemlock component has precipitously declined in many forests of the state. Hemlock formerly covered 13.5% of the landscape and now comprises less than 1% of forest land, declining by over 97% from an area of 4.7 million acres to little more than 100,000 acres (Table 3.2). Hemlock was a co-dominant species in 6.3 million acres (85%) of the circa 1800 northern hardwood forests, both in terms of density and dominance (Tables 2.1 through 2.3). In the circa 1800 landscape there were four primary hemlock associations: pure hemlock (902,000 acres), hemlock/white pine (1,060,000 acres), hemlock/sugar maple (2,326,000 acres), and hemlock/yellow birch (295,000 acres). The decline in hemlock can be attributed to several factors, including climate, disturbance, land-use history and reproductive/life-history requirements of the species (Mladenoff and Sterns 1993). In the late 1800s, large areas of hemlock were harvested for the bark, which was used in tannin mills. The primary controlling factor governing rates of hemlock regeneration is likely the presence or absence of residual seed trees. Other factors are the shade-tolerant nature of hemlock, the historic occurrence of frequent destructive fires, the elimination of large-diameter woody debris nurse logs, and increased herbivore pressure, which have combined to inhibit the effective recruitment of hemlock throughout many portions of the landscape.

Since circa 1800, the mesic southern hardwoods community type has declined by 4.3 million acres (74%) from almost 17% to 8% of the forested landscape (Table 3.2). In large part this loss is due to conversion of this forest type to farmland and progressively to urban/open land, which when combined now occupy over 15 million acres of the landscape (Figure 3.4). There are currently 39 documented occurrences totaling 2,505 acres of the mesic southern hardwoods community in Michigan. Of these, only six occurrences totaling less than 100 acres are high quality representations of this cover type (Cohen 2004).

Mixed conifer swamps declined by almost 3.6 million acres (84%) since circa 1800, from over 12% to under 4 % of the forest landscape (Table 3.2). This loss can be

attributed to two primary factors: the historic clearing and draining of portions of this community type for agriculture, and the logging and conversion of the community to shrub-carr wetlands, which have increased in extent by almost three-quarter of a million acres. Conversely, the acreage of cedar swamps has increased by almost 8 percent since circa 1800, and has almost doubled its relative coverage of the landscape. Growth of cedar is more than twice the losses from mortality and removals (Table 3.3). However, natural mortality is almost twice the volume of cedar that is removed by harvest. Of note, the growth and mortality of black spruce is similar to that of cedar, with excessive losses due to mortality.

There are three historic primary pine associations in Michigan: the mesic white/red pine forest, the dry northern forest dominated by jack and red pine, and the dry-mesic northern forest dominated by white pine and oak species. When considering the white pine communities (Table 3.2), the greatest changes are apparent in the various white pine communities, which have declined by over 80% (2.4 million acres in aggregate), from almost 7% to little more than 2% of the landscape. The mixed pine/oak forest type (82% of which historically consisted of white pine and white oak) has declined by almost 200,000 acres (35%) since circa 1800. These declines may be attributed to the historic loss of white pine seed trees from the landscape and repeated wildfires during the post-logging era, which greatly inhibited the natural reproduction of this species. Conversely, relatively pure red pine forests have increased by almost 300,000 acres (51%), and relatively pure jack pine communities have increased by over 118,000 acres (20%). However, even with this increase the proportion of pine dominated forests in the overall landscape has decreased by over 1.7 million acres. Remants of the dry northern and dry-mesic northern pine forests are among the rarest forest types in the Great Lakes region. Just over 0.2% of dry-mesic northern forest remains in presettlement condition in Michigan, with 34 documented occurrences. Of these, only 9 occurrences constituting just over 4,000 acres are of high quality (Cohen 2002a). There are 14 documented occurrences of the red pine variant of the dry northern forest in Michigan. Only 6 of these occurrences totaling over 600 acres are of high quality (with large boles and a more open, two-tiered canopy structure). The jack pine variant of the dry northern forest is more secure in Michigan, totaling over 333,000 acres (Cohen 2002b).

Intensive re-forestation efforts in the early to mid 1900s have contributed to a doubling of the area of white, red and jack pine forests since 1935 (Figure 3.5) to around 2 million acres. Due to this effort, the restored pine forests are a resource that would have otherwise not existed in any significant volume. However, these efforts initiated the management of white, red and jack pine as monocultures, which have been perpetuated due to economic efficiency and demand. This requires less complicated silvicultural management techniques but also results in less landscape biodiversity. The complex composition and structure of circa 1800 dry northern, dry mesic, and pine and pine/oak barrens are barely represented in the current forest landscape. Furthermore, the modern exclusion of frequent and large scale fires from the forested landscape has greatly suppressed the natural regeneration of shade intolerant pine species. There is evidence that mid-shade tolerant white pine is regenerating in the understory of many current oak, red pine and aspen stands, portending a resurgence in the mixed pine/oak and mixed red/white pine forest types. This trend is discussed further in the next section.

The mixed oak savanna, oak/pine barrens and prairie communities were significant components of the circa 1800 landscape, occupying over 2.1 million acres in mostly the Southern Lower Peninsula (Table 3.2). Due to the suppression of wildfires and their ease of conversion to agricultural land, these communities have declined by over 99%, and are now only represented by small fragments that are scattered throughout the landscape. There have been major ecological consequences for plant and animal species that were adapted to savanna and prairie communities as they have also largely disappeared from the landscape and many remain imperiled as threatened and endangered species. In the Northern Lower Peninsula, circa-1800 pine barren communities covered almost 270,000 acres of the landscape. Today fewer than five high quality occurrences are known in Michigan, totaling only a few hundred acres.

3.1.2 - DNR-Owned Forest Land Conditions and Trends

The 3.9 million acres that are contained and managed by the DNR within the State Forest System (Figure 1.3) are largely non-contiguous tracts of forest that are scattered throughout the landscapes of the northern Lower Peninsula of Michigan and all of Upper Peninsula of Michigan. Over half (51.6%) of DNR-owned forestland is located in the Northern Lower Peninsula ecoregion. The Eastern Upper Peninsula and Western Upper Peninsula ecoregions contain 26.5% and 21.9% of forestland respectively (Appendix G). In contrast to the statewide landscape, the largest DNR community type is aspen at 885,000 acres (22 percent), followed by northern hardwoods at 508,000 acres (13 percent), jack pine at 367,000 acres (9 percent), red pine at 280,000 acres (7 percent), mixed swamp conifers at 261,000 acres (6 percent), oak at 244,000 acres (6 percent), and cedar swamp at 228,000 acres (6 percent) (Table 3.4). The current land base has changed significantly from circa-1800 conditions, where two community types were then dominant: northern hardwoods (26%) and mixed conifer swamps (22%) (Table 3.5). Two other major community types of the circa 1800 period were mixed red and white pine forests and jack pine forests, where both represented around 10% of the area that is now the State Forest. This section contains a more detailed discussion of the conditions and trends in the current cover types upon DNR-owned forest land.

Aspen

Consistent with statewide data, the acreage of aspen upon the State Forest is many times its historical acreage (Table 3.5), as a large number of acres of other cover types were converted to aspen after the logging era. There are more acres of aspen on the State Forest than any other type, and the acreage of this cover type has been fairly constant (Table 3.4). Nearly 60% of aspen is located in the Northern Lower Peninsula ecoregion (520,626 acres). Over a quarter (27.3%) of aspen (241,408 acres) is located in the Western Upper Peninsula ecoregion. Aspen is a relatively small component (13.9%) of the Eastern Upper Peninsula ecoregion with only 122,788 acres (Appendix G).

Multiple markets began developing for Michigan aspen in the 1960s, and aspen fiber is now in strong demand by the forest products industry. Aspen also provides good habitat for a number of highly desired wildlife species (such as deer, grouse and woodcock). These species are adapted to and have been heavily favored by the preponderance of early successional forest types over the last century, and for which hunting groups and persons who simply enjoy viewing wildlife have an inherent

Table 3.4. Change in acreage by cover type of State Forest Land for 1988-2006. (Unpublished DNR Inventory Data, 2006)

Cover Type	1988 Acreage	1997 Acreage	2006 Acreage	1988 Percent	1997 Percent	2006 Percent	Absolute Change 1988-06	Percent Change fm 1988
Aspen	893,279	909,964	884,822	23.2%	23.1%	22.5%	-8,457	-0.9%
Balsam Poplar Swamp	52,536	60,641	71,655	1.4%	1.5%	1.8%	19,119	36.4%
Bedrock	1,066	1,218	1,065	0.0%	0.0%	0.0%	-1	-0.1%
Black Spruce Swamp	69,082	68,145	68,636	1.8%	1.7%	1.7%	-446	-0.6%
Bog or Marsh	49,045	43,267	35,163	1.3%	1.1%	0.9%	-13,882	-28.3%
Cedar Swamp	187,115	206,954	228,397	4.9%	5.3%	5.8%	41,282	22.1%
Emergent Marsh	93,285	113,866	113,355	2.4%	2.9%	2.9%	20,070	21.5%
Grassland	177,114	151,514	125,288	4.6%	3.8%	3.2%	-51,826	-29.3%
Hemlock	12,580	14,810	17,479	0.3%	0.4%	0.4%	4,899	38.9%
Jack Pine	401,705	375,220	367,034	10.4%	9.5%	9.3%	-34,671	-8.6%
Local Name	7,611	16,611	6,544	0.2%	0.4%	0.2%	-1,067	-14.0%
Lowland Hardwoods	107,890	121,442	135,912	2.8%	3.1%	3.5%	28,022	26.0%
Mixed Swamp Conifers	260,426	263,205	261,183	6.8%	6.7%	6.6%	757	0.3%
N. Hdwds	499,262	503,371	508,302	12.9%	12.8%	12.9%	9,040	1.8%
Non Stocked	30,499	32,665	22,791	0.8%	0.8%	0.6%	-7,708	-25.3%
Oak	243,010	246,966	243,691	6.3%	6.3%	6.2%	681	0.3%
Paper Birch	55,246	47,395	35,462	1.4%	1.2%	0.9%	-19,784	-35.8%
Red Pine	235,249	263,945	279,973	6.1%	6.7%	7.1%	44,724	19.0%
Sand Dune	729	795	1,106	0.0%	0.0%	0.0%	377	51.7%
Scrub-Carr Wetland	201,154	193,822	197,448	5.2%	4.9%	5.0%	-3,706	-1.8%
Spruce Fir	65,281	51,718	51,504	1.7%	1.3%	1.3%	-13,777	-21.1%
Tamarack Swamp	16,540	20,732	22,256	0.4%	0.5%	0.6%	5,716	34.6%
Treed Bog	60,594	60,430	62,692	1.6%	1.5%	1.6%	2,098	3.5%
Upland Brush	43,351	46,657	53,008	1.1%	1.2%	1.3%	9,657	22.3%
Water	36,173	43,980	47,751	0.9%	1.1%	1.2%	11,578	32.0%
White Pine	55,703	77,428	93,568	1.4%	2.0%	2.4%	37,865	68.0%
Totals	3,855,525	3,936,761	3,936,085	100.0%	100.0%	100.0%	80,560	2.1%

interest in maintaining at high population levels. Due to these factors and to avoid the succession of the type, much of the commercially desirable acres were harvested by the mid-to late 1990s for the purpose of maintaining a large land base of aspen for the future.

Heavy rates of harvest over the past few decades have perpetuated an unbalanced age class distribution, with a large acreage of stands in the 10-40 year age classes (Appendix H). The largest change in size class has occurred in the medium to well-stocked pole timber class, which has declined by over 96,000 acres since 1988 (Table 3.6). There has been a corresponding change in well-stocked sapling stands, which have increased by over 91,000 acres during the same time period. Over half (459,000 acres) of the current aspen land base is in the well-stocked sapling size class, again emphasizing the current skewed age class distribution of the aspen cover type.

Table 3.5. Change in Cover Type circa 1800 to 2006 by acreage and relative cover.
(Michigan Natural Features Inventory, 1998 and MDNR, 2006)

Cover Type	C1800 Acreage	C1800 Percent	2006 Acreage	2006 Percent	Change in Acres	Change in Percent
Aspen/Birch Forest	52,541	1.3	920,284	23.4	867,743	1651.6
Bedrock	1,174	0.0	1,065	0.0	-109	-9.3
Cedar Swamp	219,348	5.5	228,397	5.8	9,049	4.1
Grassland	3,715	0.1	125,288	3.2	121,573	3272.8
Hemlock (C1800 Hemlock/W Pine/Y Birch)	345,242	8.7	17,479	0.4	-327,763	-94.9
Jack Pine (C1800 JP/RP) Forest	400,793	10.1	367,034	9.3	-33,759	-8.4
Lake/River	24,025	0.6	47,751	1.2	23,726	98.8
Mixed Conifer Swamp (incl 2006 Blk Spr and Tam)	874,952	22.0	352,075	8.9	-522,877	-59.8
Mixed Hardwood and Black Ash Swamp	26,023	0.7	207,567	5.3	181,544	697.6
Mixed Pine-Oak Forest (2006 Oak)	72,176	1.8	243,691	6.2	171,515	237.6
Muskeg/Bog	124,775	3.1	97,855	2.5	-26,920	-21.6
Non-Stocked-Local Name	0.0	0.0	29,335	0.7	29,335	100.0
Northern Hardwoods [1]	1,017,565	25.6	508,302	12.9	-509,263	-50.0
Oak-Pine Barrens	13,215	0.3	0.0	0.0	-13,215	-100.0
Pine Barrens	88,070	2.2	0.0	0.0	-88,070	-100.0
Red Pine Forest	20,798	0.5	279,973	7.1	259,175	1246.2
Red Pine-White Pine Forest	385,600	9.7	0.0	0.0	-385,600	-100.0
Sand Dune	202	0.0	1,106	0.0	904	447.1
Shrub Swamp/Emergent Marsh	56,808	1.4	310,803	7.9	253,995	447.1
Spruce-Fir (C1800 Spr-Fir-Cedar) Forest	136,148	3.4	51,504	1.3	-84,644	-62.2
Upland Brush	0.0	0.0	53,008	1.3	53,008	100.0
White Pine Forest	19,536	0.5	93,568	2.4	74,032	379.0
White Pine-Mixed Hardwood Forest	84,832	2.1	0.0	0.0	-84,832	-100.0
White Pine-White Oak Forest	3,096	0.1	0.0	0.0	-3,096	-100.0
Totals	3,970,634	100.0	3,936,085	100.0	-34,549	-0.9

[1] Includes C1800 Beech-Sugar Maple-Hemlock, Sugar Maple-Basswood, Sugar Maple-Hemlock, and Sugar Maple-Yellow Birch Cover Types.

Table 3.6. Acreage of aspen size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data.)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	893,186	584	3,705	15,159	38,029	113,449	280,581	8,328	60,031	368,235	5085
2006	884,822	290	2,314	11,964	42,519	94,845	201,780	9,241	55,460	459,412	6997
Change	-8,364	-294	-1,391	-3,195	4,490	-18,604	-78,801	913	-4,571	91,177	1912
% Change	-0.9%	-50.3%	-37.5%	-21.1%	11.8%	-16.4%	-28.1%	11.0%	-7.6%	24.8%	37.6%

Given the monotypic clonal life cycle of aspen, compositional and structural diversity is low in these stands. However, consistent with state wide trends some aspen acres are becoming more diverse as they succeed to other cover types (Table 3.7). Without alternative management to the contrary, it is apparent that a substantial acreage of aspen has the potential to succeed to a spruce/fir community or to northern hardwoods. Lesser amounts of acreage are succeeding to white pine, oak and lowland hardwoods. These areas total over 325,000 acres, and represent almost 37% of the current 885,000 acre land base of aspen. Estimated mortality of aspen exceeds removals by a ratio of almost 2:1 (Table 3.8). However, estimated growth of aspen still exceeds mortality and removals by a similar 2:1 ratio, and young aspen is present in the understory of almost 20,000 acres of existing oak stands and on over 18,000 acres of current red pine stands.

In a fifty-year rotation where acres were evenly distributed (what foresters refer to as having reached "regulation" or "area regulation"), 20% of the total acres would be in each ten-year age class. However, aspen harvests have fallen off so sharply in the past decade (due to heavy cutting in the prior decade) that the youngest (0-9) age class has slightly less than ten percent of the total acres. This is creating a "boom and bust" legacy problem for wildlife habitats and populations as well as for the wood products industry.

Table 3.7. Acreage of primary understory types by deciduous cover type for 2006. (Unpublished DNR Inventory Data)

	Deciduous Cover Type:					
Understory Type	Aspen	Balsam Poplar	Oak	Paper Birch	Lowland Hardwoods	Northern Hardwoods
Not typed	43					
Aspen	355,919	898	19,868	755	1,589	7,932
Balsam Poplar	355	13,466			329	77
Bedrock	55					
Black Spruce	2,111	566		86	431	107
Bog or Marsh	770	46	182	4	18	
Cedar Swamp	1,432	696		119	521	21
Emergent Marsh	158	411		14	811	130
Grassland	37,362	871	2,355	13	303	3,206
Hemlock	50		19	43	166	635
Jack Pine	6,760	51	8,431		39	496
Local Name	0		206		28	16
Lowland Hrdwds	21,356	5,470	6,855	296	73,833	513
Lowlnd Brush	14,434	15,526	70	795	21,018	203
Mxd Swmp Cnfr	1,785	6,848	20	978	10,823	325
N. Hardwoods	123,316	2,205	67,307	8,196	3,033	440,363
Non-Stocked	81,092	3,234	7,181	823	3,465	8,007
Oak	25,331	154	75,571	209	907	2,293
Paper Birch	656	93	51	1,170	12	110
Red Pine	4,476	59	3,725	120	3	320
Sand Dune	21		6			9
Spruce Fir	127,927	20,390	1,302	20,209	16,027	34,898
Tamarack Swmp	236		13	7	3	4
Treed Bog	23				45	
Upland Brush	52,043	510	13,413	563	544	3,960
Water	0				190	
White Pine	27,111	161	37,116	1,062	1,774	4,677
Totals	884,822	71,655	243,691	35,462	135,912	508,302

Table 3.8. Volume of growth, mortality and removals by forest type on State Forest Land for 2003 (in cubic feet).
(U. S. Forest Service, 2003)

Forest Type	State Growth	State Mortality	State Removals	Total Mortality & Removals	Growth to Total Mort & Remvl Ratio	Growth to Mortality Ratio	Growth to Removal Ratio	Mortality to Removal Ratio
Aspen	35,263,662	13,255,237	6,888,334	20,143,571	1.8	2.7	5.1	1.9
Balsam Fir	1,109,695	464,282	1,807,010	2,271,292	0.5	2.4	0.6	0.3
Balsam Poplar	2,972,021	134,548		134,548	22.1	22.1		
Birch	901,710	136,841		136,841	6.6	6.6		
Black spruce	6,748,311	1,370,791	288,190	1,658,981	4.1	4.9	23.4	4.8
Cottonwood / Willow	1,094,569							
Eastern white pine	3,024,009	298,372	2,520,544	2,818,916	1.1	10.1	1.2	0.1
Jack pine	7,855,067	1,737,656	6,209,000	7,946,656	1.0	4.5	1.3	0.3
Lowland Hrdwoods	3,881,930	5,565,047	1,237,743	6,802,790	0.6	0.7	3.1	4.5
Non stocked	1,459,919	584,980	5,040,497	5,625,477	0.3	2.5	0.3	0.1
N. Hardwoods	47,330,507	8,919,055	18,409,438	27,328,493	1.7	5.3	2.6	0.5
N. White Cedar	8,835,188	6,088,584		6,088,584	1.5	1.5		
Oak	11,904,777	5,818,525	14,130,589	19,949,114	0.6	2.0	0.8	0.4
Other	6,933,560	1,490,077		1,490,077	4.7	4.7		
Other softwoods	655,748		167,161	167,161	3.9		3.9	0.0
Red Pine	18,534,527	3,002,901	4,594,272	7,597,173	2.4	6.2	4.0	0.7
Tamarack	2,754,434	520,184		520,184	5.3	5.3		
White Spruce	1,780,917							
Totals	163,040,552	49,387,081	61,292,779	110,679,860	1.5	3.3	2.7	0.8

Note: Sampling error estimate of most data is greater than 50%.

Northern Hardwoods

The northern hardwoods cover type is the second-largest acreage on State Forest Land at over 508,000 acres or 13% of the land base. Since most northern hardwood stands are uneven-aged (Appendix H) and the tree species that compose the type have varying growth characteristics, total basal area is a better measure for northern hardwood conditions and treatment decisions than is the age class distribution. In the past decade, timber harvests in northern hardwoods (mostly single tree selection) have surpassed aspen in accounting for the most annual harvest acres.

Northern hardwood acreage has increased only slightly since 1988 (Table 3.4). The Northern Lower Peninsula ecoregion has the largest (40.8%) acreage of northern hardwoods on state forestland at over 207,000 acres. The Western Upper Peninsula and the Eastern Upper Peninsula ecoregions have 171,749 (33.8%) and 129,254 (25.4%) acres of northern hardwoods forestland respectively (Appendix G).

Consistent with statewide trends since circa 1800, the acreage of northern hardwoods decreased by over a half-million acres (-60%), with many of these acres having been converted to other cover types such as aspen, oak and red pine in the post-logging era (Table 3.5). Most northern hardwood acreage is in the well-stocked pole and saw size classes (Table 3.9). The largest changes in size class distribution occur with a 65,000 acres decline in pole timber and a 70,000 acre increase in saw timber classes,

Table 3.9. Acreage of northern hardwoods size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	499,262	741	5,732	62,359	16,115	59,263	343,907	841	4,332	5,159	813
2006	508,302	1,553	6,984	130,612	8,382	38,885	306,692	1,011	5,321	8,750	112
Change	9,040	812	1,252	68,253	-7,733	-20,378	-37,215	170	989	3,591	-701
% Change	1.8%	109.6%	21.8%	109.5%	-48.0%	-34.4%	-10.8%	20.2%	22.8%	69.6%	-86.2%

Table 3.10. Acreage of basal area stocking of Northern Hardwoods on State Forest Land for 1988-2006.
(Unpublished DNR Inventory Data)

Inventory	Total Acres	BA <60	BA 60	BA 70	BA 80	BA 90	BA 100	BA 110	BA 120	BA 130	BA 140	BA > 150
1979-1988	499,262	56,803	34,750	46,154	66,590	78,969	68,015	58,483	43,641	22,861	10,898	12,098
1988-1997	503,371	47,601	29,874	40,432	66,719	79,332	73,568	64,817	44,922	28,013	15,539	12,554
1997-2006	508,302	42,958	25,260	52,295	89,042	76,281	71,696	54,132	43,397	26,877	14,755	11,609

reflecting a continuing maturing of this cover type. The acres within each basal area class are relatively stable across the past three inventories (Table 3.10). Exceptions to this include the most recent inventory which has fewer acres in the two smallest basal area categories shown (<60 and 60) and fewer acres in the 110 basal area class. However, there are more acres in the 70 and 80 basal area categories, in line with increased harvests of this type since the early 1990s.

Consistent with the life history characteristics of its component species, the estimated growth of northern hardwoods is one and a half times the volume of mortality and removals in the current acreage of the cover type (Table 3.8), and the understory type on 440,000 acres of northern hardwoods is predominately the same as the overstory species (Table 3.7). The only other significant understory recruitment is by the shade tolerant conifers white spruce and balsam fir on 35,000 acres. Interestingly, northern hardwoods are predominant in the understory of 123,000 acres of existing aspen stands, over 67,000 acres of existing oak stands, and over 44,000 acres of current red pine stands, indicating potential succession in the direction of the circa 1800 northern hardwoods cover type on these sites.

Jack Pine

The acreage of jack pine in the State Forest has been fairly consistent since circa 1800, having only slightly decreased (Table 3.5). This is not surprising given large areas of xeric, outwash soil types within the State Forest, to which the species is well adapted and competitive. Jack pine currently covers 367,000 acres of the State Forest, with a slight decline of 35,000 acres (8.6%) since 1988 (Table 3.4). The

greatest acreage (almost 234,000 acres or 63.7%) of jack pine upon state forestland is located in the Northern Lower Peninsula ecoregion. The Eastern Upper Peninsula ecoregion also contains a significant acreage (over 105,000 acres or 28.6% of the type) of jack pine. There is relatively little jack pine (28,000 acres or 7.7%) in the Western Upper Peninsula ecoregion (Appendix G).

The Jack pine type is the only seral forest type that is somewhat balanced at approximately 40,000 acres per age class, although there is a moderate spike in the 0-20 year age classes (Appendix H). This reflects an emphasis upon salvage harvests of older age-classes of jack pine before they succumb to budworm infestations, and efforts to cut many older stands to preclude natural mortality. There remains a significant acreage of jack pine exceeding sixty years of age for which mortality from budworm continues to be a concern. Over 80% of jack pine stands are managed in even-aged 60-year rotations, although concerns over budworm and associated mortality are engendering considerations of a 50-year rotation.

Consistent with the ecology of jack pine and the habitat type upon which it occurs there is little natural succession occurring in the community. Other than jack pine itself, the most prevalent understory species is oak upon 43,000 acres (Table 3.11). Estimated

Table 3.11. Acreage of primary understory types by conifer cover types for 2006. (Unpublished DNR Inventory Data)

	Conifer Cover Type:								
Understory Type	Black Spruce	Cedar Swamp	Hemlock	Jack Pine	Mixed Swamp Conifers	Red Pine	Spruce Fir	Tamaracok Swamp	White Pine
Not typed									
Aspen	132	768	107	9,531	698	18,229	2,660	3	7,312
Balsam Poplar	9	654	32	78	604	38	289	1	140
Bedrock		5		72		50			30
Black Spruce	46,394	2,786	121	13,524	6,824	5,062	344	2,055	2,799
Bog or Marsh	728	120		98	107	502	16	16	17
Cedar Swamp	426	57,248	248	29	7,209	1	146	929	32
Emergent Marsh	8	261		304	265			129	38
Grassland	151	389	104	10,590	1,343	3,341	1,556	45	514
Hemlock		41	2,787		203	63			106
Jack Pine	141			195,754	29	13,563	66	4	1,078
Local Name				175		10			
Lowland Hrdwds	287	14,029	369	1,668	9,264	1,706	347	237	1,014
Lowlnd Brush	4,706	20,424	118	1,514	40,958	470	757	8,143	275
Mxd Swmp Cnfr	6,042	67,507	1,551	418	138,870	656	552	2,473	1,337
N. Hardwoods	231	1,263	3,270	11,979	2,818	44,432	1,896	167	10,562
Non-Stocked	3,259	16,578	1,763	41,007	7,882	53,380	4,389	619	3,110
Oak	48	3		42,743	23	25,762		14	1,113
Paper Birch	21	187		55	19	79	64		96
Red Pine				8,428		55,036	11		362
Sand Dune		12			59				
Spruce Fir	5,835	45,156	6,331	6,148	42,489	13,255	37,104	1,331	21,067
Tamarack Swmp	34	359		44	192	35	35	6,000	7
Treed Bog	32			137	16				
Upland Brush	87	553	54	10,065	861	7,743	1,004	62	974
Water		30							
White Pine	65	24	624	12,673	450	36,560	268	28	41,585
Totals	68,636	228,397	17,479	367,034	261,183	279,973	51,504	22,256	93,568

Table 3.12. Acreage of Jack Pine size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data.)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_ BA)	Medium Stocked (40-69 SQ_FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (10-39 SQ_FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	401,705	58	633	1,427	34,832	86,857	141,609	15,001	45,379	59,315	16,594
2006	367,034	380	1,590	1,804	22,071	47,570	97,378	10,656	28,020	134,665	22,900
Change	-34,671	322	957	377	-12,761	-39,287	-44,231	-4,345	-17,359	75,350	6306
% Change	-8.6%	555.2%	151.2%	26.4%	-36.6%	-45.2%	-31.2%	-29.0%	-38.3%	127.0%	38.0%

growth of jack pine is about equal to losses through mortality and removals (Table 3.8). Since 1988 there has been a 96,000 acre decline in pole timber classes, and a corresponding 73,000 acre increase in the seedling class (Table 3.12). Overall there are a disproportionate number of acres in the well-stocked seedling and medium to well-stocked pole timber classes. To some degree, this is as a result of management of many jack pine stands for Kirtland's Warbler habitat, which is solely dependent upon young and dense (6-21 year old) jack pine stands for its survival.

Red Pine

In circa 1800, there were over 406,000 acres of red pine (predominantly mixed red and white pine associations) in the State Forest, representing over 10% of the forested land base (Table 3.5). There are currently 80,000 acres of red pine in the State Forest, mostly managed in mono-culture plantations (Table 3.4). The great majority (181,445 acres or 64.8% of the type) of red pine state forestland is located in the Northern Lower Peninsula ecoregion. The Eastern Upper Peninsula ecoregion also contains a significant acreage of red pine with 77,776 acres, or 27.8% of all red pine acres. There are relatively few red pine acres (20,752 acres or 7.4%) in the Western Upper Peninsula ecoregion (Appendix G). There has been a 45,000 acre (19%) statewide increase in red pine acres since 1988, although the acreage of seedling stands dropped by 58% (34,000 acres) over this same time period (Table 3.13).

Estimated growth in red pine is almost 2.5 times that of mortality and removals (Table 3.8). The age class distribution of red pine is heavily skewed to older aged stands (Appendix H). There is a large acreage of stands in the 40-79 year age classes which correlates with intensive planting programs in the 1930s by the CCC and the state of Michigan in the 1950s. Accordingly, acreages of both well-stocked pole (up 38%) and well-stocked saw (up 95%) timber classes increased over 34,000 acres (Table 3.13). Very little red pine exists under 40 years of age. Artificial regeneration by planting is required for reliable re-establishment of most stands due to unpredictable seed production and the species' shade-intolerant nature. From the 1970s to the present, regeneration has been fairly consistent at 10,000 acres per age class.

Due to fire suppression and competition on higher quality mesic (typically former northern hardwood) sites, many red pine stands in older age classes are succeeding to

Table 3.13. Acreage of Red Pine size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	235,249	4,574	13,562	36,631	7,615	20,672	91,300	3,462	15,374	40,851	1,208
2006	279,973	6,815	24,148	71,477	6,292	18,455	125,570	672	3,010	21,549	1,985
Change	44,724	2,241	10,586	34,846	-1,323	-2,217	34,270	-2,790	-12,364	-19,302	777
% Change	19.0%	49.0%	78.1%	95.1%	-17.4%	-10.7%	37.5%	-80.6%	-80.4%	-47.2%	64.3%

more shade tolerant species, as demonstrated by northern hardwoods predominating the understory on over 44,000 acres of red pine stands (Table 3.11). Interestingly, white pine and oak are dominant in the understory of 37,000 acres and 26,000 acres respectively, indicating some return of the mixed red/white pine and mixed pine/oak communities of the circa 1800 forest landscape. Aspen is in the understory of an additional 18,000 acres. All together these understory cover types represent a total of 125,000 acres or 45% of the current 280,000 acre red pine land base. Thus, a sizeable fraction of existing red pine stands has potential to succeed to mixed stands and other forest types in the future. Red pine is a fast growing species and higher values are received for logging in pure, uniformly-sized stands, but many of the conversions will likely be allowed to occur due to site suitability, wildlife and biodiversity concerns.

With these succcessional trends in mind, the adoption of management prescriptions as described in Guidelines for Red Pine Management (Michigan Department of Natural Resources 2006) portend further diversification of red pine stands in the future. The genesis of these guidelines was to restore some balance to the age class structure and reduce the pressures for much higher treatments in two to four decades by engaging in more harvests now. A major outgrowth of the project was to assess the suitability of sites where red pine is currently located and where it should be considered for regeneration based on habitat typing (see Burger and Kotar 2003). This information is helpful in clarifying the basis for where red pine is a poor choice because of physical factors. Often where it is well-suited, other forest species also are well-suited and preferred over red pine for wildlife values. It is expected that further clarification of procedures for weighing timber and wildlife values at the stand, landscape, and state level will come in future years through established planning, public participation and management review processes.

Mixed Swamp Conifers

The acreage of mixed swamp conifers has remained almost static since 1988, comprising over 261,000 acres of the State Forest (Table 3.4), but the cover type has declined by almost 523,000 acres (60%) since circa 1800 (Table 3.5). The distribution of the cover type is fairly balanced across all ecoregions, with 94-98 thousand acres (36-37% of the type) located in the Northern Lower and Western Upper Peninsulas and over 69,000 acres (almost 27%) in the Eastern Upper Peninsula (Appendix G).

The age class distribution of mixed swamp conifers and black spruce are skewed to the older age classes (60 to 100+ years old) (Appendix H). There is relatively little active management of these community types, which has implications for increased forest health issues and natural mortality within the types. Most acreage of mixed swamp conifers is in the pole timber size class (Table 3.14), which increased by over 12,000 acres since 1988. Corresponding decreases were recorded in the acreage of the seedling-sapling size class. Other than in-kind recruitment, the only other association that is predominant in the understory is shade tolerant spruce/fir species on 42,000 acres (one-sixth) of the current acreage of the mixed swamp conifer cover type. An understory of mixed swamp conifers is present on over 67,000 acres of current cedar swamp cover type, reflecting a greater diversification of species within the cedar cover type (Table 3.11). For the black spruce component of this cover type, estimated growth is 4 times that of mortality and removals. However, natural mortality is estimated to be almost 5 times that of removals (Table 3.8).

Table 3.14. Acreage of Mixed Swamp Conifers size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data.)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	260,426	25	91	878	23,214	56,543	150,459	3,344	13,642	11,737	493
2006	261,183	30	139	1,441	22,576	59,333	160,181	1,364	6,045	9,692	382
Change	757	5	48	563	-638	2,790	9,722	-1,980	-7,597	-2,045	-111
% Change	0.3%	20.0%	52.7%	64.1%	-2.7%	4.9%	6.5%	-59.2%	-55.7%	-17.4%	-22.5%

Oak

The acreage of oak has remained fairly steady since 1988, covering 244,000 acres of the State Forest (Table 3.4). The overwhelming predominance of oak acreage (229,682 acres or 94.3% of the type) is located in the Northern Lower Peninsula ecoregion. There are very few acres of oak (only 2-4% of the type) in the Eastern and Western Upper Peninsula ecoregions (Appendix G).

Oak species were often a component of mixed pine-oak cover types in the pre-settlement landscape of upper Michigan, but was only a relatively minor cover type (72,000 acres or 2%) of the Circa 1800 State Forest land base (Table 3.5). The age class distribution of current oak forests is greatly unbalanced, with approximately 65% of oak stands between 70 and 100 years of age and with to 32% concentrated in the 80 to 90 year old age class (Appendix H). The 0-70 year age classes are more balanced, with a consistent recruitment of about 10,000 acres for each class. The DNR uses a silvicultural rotation age of eighty years, which means that for stands older than eighty years of age a limiting factor must be coded into the inventory database if it is not prescribed for treatment. In the case of oak, the persistence of this cohort is a

result of intentional retention of oak species for hard mast production. Most of the acreage of oak lies in the medium and well-stocked pole and saw timber size classes (Table 3.15). There are relatively fewer acres of oak in the sapling size class, reflecting problems in achieving adequate regeneration of oak. However, percentage increases in sapling acres show an improving trend in regeneration.

Of the major cover types on State Forest Land, oak is the only type in which estimated mortality and removals exceed growth, by an almost 2:1 ratio (Table 3.8). This is mostly due to removals, which alone exceed growth and which are more than twice that of estimated mortality. Oak-dominated stands common on moderate to low quality, sandy soil sites are anomalies which resulted from the removal of the pre-settlement pine forest and the unnatural catastrophic fires that followed. The 70-90 age cohort is a legacy of these large tracts of burnt over land, where in the early 1900s the regeneration of seral oak was favored over more shade tolerant species, and where historic seed sources of pine were then absent from the landscape. Maintenance of this cover type at its current level is not possible without replicating the events of the past – which will certainly not occur.

Although some recruitment of oak is occurring in the understory of almost 76,000 acres of oak stands, the presence of other types in the understory indicates that much of the oak resource (124,000 acres (51%) of the current 244,000 acre oak land base) has the potential to succeed to other forest cover types (Table 3.7), with white pine and red maple on moderate to low quality sites, and to sugar maple-beech types on higher quality sites. The continued existence of an oak component on higher quality northern hardwood sites will require silvicultural practices that benefit oak's mid-tolerant shade characteristics and that overcome its difficulty in out-competing more shade tolerant, northern hardwood species. The recruitment of white pine in the understory represents a return of the mixed pine/oak community, which was a significant community in the circa 1800 landscape. On a positive note, oak is present in the understory of 43,000 acres of existing jack pine stands, 26,000 acres of red pine stands, and over 25,000 acres of current aspen stands, representing a potential future oak component on these sites. Oak remains a valuable resource to maintain on the landscape, and on moderate and low- quality sites, silvicultural practices that encourage its establishment and recruitment as part of a mixed pine-oak cover type should be employed.

Table 3.15. Acreage of Oak size classes and stocking on State Forest Land for 1988 and 2006. (Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	243,010	6,077	15,159	22,306	9,168	48,458	119,916	2,689	9,230	7,342	2,665
2006	243,691	11,911	32,646	49,984	7,455	28,525	74,920	4,617	16,021	16,851	761
Change	681	5,834	17,487	27,678	-1,713	-19,933	-44,996	1,928	6,791	9,509	-1904
% Change	0.3%	96.0%	115.4%	124.1%	-18.7%	-41.1%	-37.5%	71.7%	73.6%	129.5%	-71.4%

Cedar Swamp

Cedar swamps are present on 228,000 acres of State Forest land, having increased by over 41,000 acres (22%) since 1988 (Table 3.4). The majority of state forest cedar acreage is in the Eastern Upper Peninsula, at 99,510 acres or 43.6% of the type. The remaining acreage is split between the Northern Lower and Western Upper Peninsula ecoregions, with 67,548 and 61,339 acres respectively (Appendix G).

The current acreage of cedar is fairly consistent with the pre-settlement acreage of 219,000 acres (Table 3.5). Some of the recent increase may be the result of succession from shrub-carr wetland, but may also be a result of more accurate mapping of forest compartments. Most acreage lies in the well stock pole timber size class (Table 3.16), which has increased by 35% during this same time period. Growth exceeds natural mortality by a ratio of 1.5:1 (Table 3.8). The age class distribution for cedar is skewed to older age classes (Appendix H), with the 100+ age class predominating. There is very little regeneration of cedar occurring, with declining acreages of sapling size classes. Regeneration problems in many areas are the result of severe browse damage caused by white-tailed deer populations, which prefer to utilize cedar swamps in the winter as both shelter and a food source. Cedar is predominant in the understory on 57,000 acres of cedar swamp (Table 3.11). However, this is exceeded by the mixed swamp conifer and spruce/fir forest types in the understory on 68,000 and 45,000 acres respectively, which portends future diversification of species upon almost half of the cedar swamp land base.

White Pine

White pine acreage increased by 38,000 acre (68%) since 1988, and the species presently covers an area of 94,000 acres of the State Forest (Table 3.4). On a percentage basis, this is the greatest rate of increase for any species, and understory data indicates that this trend is continuing. Most acres of white pine are located in the Northern Lower (45,229 acres or 48.3%) and Eastern Upper (36,902 acres or 39.4%) Peninsula ecoregions. There are currently relatively few acres of white pine (11,437 acres or 12.2%) in the state forestland of the Western Upper Peninsula ecoregion (Appendix G).

Table 3.16. Acreage of Northern White Cedar size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	187,115	17	323	2,586	8,981	26,623	132,701	876	2,898	11,922	188
2006	228,397	56	306	5,944	9,026	23,734	179,241	294	1,981	7,526	289
Change	41,282	39	-17	3,358	45	-2,889	46,540	-582	-917	-4,396	101
% Change	22.1%	229.4%	-5.3%	129.9%	0.5%	-10.9%	35.1%	-66.4%	-31.6%	-36.9%	53.7%

White pine was historically present not only in relatively pure stands (20,000 acres) but it was also a common species in several associations: the previously discussed mixed red-white pine type (386,000 acres); hemlock-white pine (314,000 acres); white pine-mixed hardwood forests (85,000 acres); and in white pine-white oak forests (3,100) acres (Table 3.5). By far, the mixed red-white pine, hemlock-white pine and white pine-mixed hardwood associations were the dominant pine communities in the circa 1800 landscape (Table 2.1, Table 3.2 and Table 3.5).

There is a large acreage of stands older than 40 years and in uneven age classes, indicating some natural recruitment of white pine around the turn of the 19th century (Appendix H). Where potential seed trees remain much natural regeneration of white pine is currently occurring in the understory of hardwood and mixed pine stands. In addition to regeneration in the understory of existing white pine stands, the species is also recruiting in the understory of aspen (27,000 acres), red pine (37,000 acres) and oak (37,000 acres) stands (Tables 3.7 and 3.11). This reflects the moderate shade tolerance of white pine, and indicates a gradual return of the white pine-mixed hardwood and the mixed red-white pine communities to the state forest landscape. Shade tolerant northern hardwoods and spruce/fir are also in the understory of about 11,000 and 21,000 respective acres of existing white pine stands (Table 3.11). These are not unexpected occurrences, since white pine was historically present as a co-dominant species in mesic northern hardwoods (Table 2.3), and white spruce and balsam fir are commonly present in remaining old growth stands of white pine.

Growth of white pine is essentially equal to removals (Table 3.8), and given the long-lived nature of the species it is not surprising that estimated mortality is low with growth approximately 10 times that of mortality. There have been large increases in pole and saw size classes since 1988, but declining regeneration in the seedling size class (Table 3.17).

Hemlock

As in the statewide landscape, hemlock was historically present in 345,000 acres of the State Forest land base in the form of hemlock-white pine and hemlock-yellow birch associations (Table 3.5). Hemlock was also a co- dominant component in the northern hardwoods cover type (Table 2.3 and Table 3.5). Today hemlock stands comprise just over 17,000 acres (0.4%) of the current State Forest land base, and it is the least

Table 3.17. Acreage of White Pine size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (10-39 SQ_FT_BA)	Medium Stocked (40-69 SQ_FT_BA)	Well Stocked (70+ SQ_FT_BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	55,703	2,711	7,793	16,792	1,665	5,892	12,917	584	2,008	5,341	0
2006	93,568	3,882	11,412	26,628	3,586	11,654	30,418	373	1,675	3,917	23
Change	37,865	1,171	3,619	9,836	1,921	5,762	17,501	-211	-333	-1,424	23
% Change	68.0%	43.2%	46.4%	58.6%	115.4%	97.8%	135.5%	-36.1%	-16.6%	-26.7%	

represented of any native tree species both in terms of absolute and percentage of acreage (Table 3.4). Most state forest hemlock acres are located in the Western and Eastern Upper Peninsula ecoregions, with 8,762 acres (50.1%) and 7,130 acres (40.8%) respectively. There is very little hemlock (1,587 acres or 9.1%) in the Northern Lower Peninsula ecoregion (Appendix G).

There has been very little hemlock regeneration over the past century, with most remaining hemlock in the 100+ year and uneven aged classes (Appendix H). Although regeneration is limited, it is still occurring. The acreage of hemlock has increased by 39% since 1988, by a total of 4,900 acres (Table 3.4). The low acreage and regeneration can be attributed to several factors, including climate, disturbance, land-use history and reproductive/life-history requirements of the species (Mladenoff and Sterns 1993). The primary controlling factor governing rates of hemlock regeneration is likely the presence or absence of residual seed trees. Other factors are the shade-tolerant nature of hemlock, the historic occurrence of frequent destructive fires, the elimination of large-diameter woody debris nurse logs, and increased herbivore pressure, which have combined to inhibit the effective reproduction of hemlock throughout many portions of the landscape.

Most hemlock is located in the well stocked pole and saw timber size classes (Table 3.18). The vast majority of understory hemlock occurs in existing hemlock stands, with lesser amounts in northern hardwoods, mixed swamp conifers, lowland hardwood and white pine stands (Table 3.11). Within existing hemlock stands the predominant understory vegetation is comprised of shade tolerant spruce/fir, northern hardwoods, hemlock, and mixed swamp conifers. Thus, where residual seed trees remain, is appears that hemlock is slowly returning to the forest landscape.

Lowland Hardwoods

Lowland hardwood cover types include balsam poplar swamp and lowland hardwoods. The acreage of balsam poplar swamp has increased by over 36% since 1988 and is approaching 72,000 acres (Table 3.4). The acreage of lowland hardwoods has increased by 26% since 1988 and now covers almost 136,000 acres. Most of the acreage of balsam poplar (41,289 acres or 57.6%) and lowland hardwoods (92,942 acres or 68.4%) is located in the Northern Lower Peninsula ecoregion. Much lower acres of balsam poplar and lowland hardwoods are present in the Eastern Upper Peninsula ecoregion, with 22,426 acres (31.3%) and 20,554 acres (15.1%)

Table 3.18. Acreage of Hemlock size classes and stocking on State Forest Land for 1988 and 2006.
(Unpublished DNR Inventory Data)

		Saw Timber			Pole Timber			Seedling-Sapling			
Year of Entry	Totals	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (10-39 SQ_ FT_ BA)	Medium Stocked (40-69 SQ_ FT_ BA)	Well Stocked (70+ SQ_ FT_ BA)	Poorly Stocked (17%-39%)	Medium Stocked (40%-69%)	Well Stocked (70%+)	Non-Stocked (Less Then 17%)
1988	12,580	32	353	5,239	42	457	6,270		64	123	
2006	17,479	124	432	7,845	135	561	8,382				
Change	4,899	92	79	2,606	93	104	2,112				
% Change	38.9%	287.5%	22.4%	49.7%	221.4%	22.8%	33.7%				

respectively. There are relatively fewer acres of balsam poplar and lowland hardwoods present in the Western Upper Peninsula ecoregion, with 7,940 acres (11.1%) and 22,416 acres (16.5%) respectively (Appendix G).

Lowland hardwoods were historically a relatively minor component of the land base that now comprises the present State Forest landscape (Table 3.5). The age class distribution for balsam poplar swamp is highly variable, with spikes in the 10-30 year and 60-90 year age classes (Appendix H). The age class distribution for lowland hardwoods is skewed to older age classes, with a large number of acres classified as uneven-aged.

Mortality of lowland hardwoods is a concern, with mortality greatly exceeding growth (Table 3.8). This mortality is due to a confluence of factors, such as forest pests, variations in ground and surface water levels, low commercial value that limits salvage cuts, accessibility concerns which limit active management, and regeneration concerns. The opposite is apparent for balsam poplar, where the growth to mortality ratio is by far the highest of any forest type.

Lowland hardwoods are regenerating well in the understory of present stands, with spruce-fir and mixed swamp conifers also becoming established on approximately 20% of the acreage (Table 3.7). Spruce-fir is the dominant component in the understory of balsam poplar stands, with balsam poplar naturally regenerating on less than 20% of the acreage.

Grasslands

Grasslands are present upon 125,000 acres (3.2%) of the State Forest, and have declined by 52,000 acres (29%) since 1988 (Table 3.4). Almost half (60,147 acres) of all state forest grasslands are located in the Northern Lower Peninsula ecoregion. A significant acreage of grasslands is located in the Eastern Upper Peninsula ecoregion, with almost 42,000 acres or 33.5% of the cover type. There is a much smaller acreage of grassland in the Western Upper Peninsula ecoregion, with 23,146 acres or18.5% (Appendix G).

Approximately 11,000 acres of grassland are co-located within the jack pine cover type. In the circa 1800 landscape of the Northern Lower Peninsula most grasslands were associated with pine and oak-pine barrens, which covered 88,000 and 13,000 acres respectively (Table 3.5). Aggregating barren habitat with the circa 1800 acreage for grasslands yields a pre-European settlement total of 105,000 acres, which is only somewhat less than the current total of 125,000 acres upon State Forest land. However, it is estimated that only approximately 1,460 acres of current DNR grassland lies within identified circa 1800 pine barren communities, so the vast majority of current grassland acres have shifted into other community types. Moreover, many additional acres of jack and red pine are currently located in areas of circa 1800 pine barren communities. There are presently less than 2,100 acres of identified pine barren remnants remaining in the state, and the community type is currently a rare occurrence upon the landscape.

3.1.3 - Timber Harvest Trends

The Michigan DNR has 60 years of historical information on timber sales. The number of timber acres sold over this period (with some variability from year to year in the number of timber acres sold) has increased appreciably, with almost 10,000 more acres being added in each successive decade (Figure 3.6). Declines in harvest over the period were followed by substantial increases. This was true of a decline between 1984 and 1989 which was followed by increases throughout most of the 1990s. Since 1999, the level of sales has dipped slightly, fluctuating between 45,000 and 58,000 acres, with an average of approximately 52,000 acres.

Five cover types (aspen, jack pine, oak, red pine, and northern hardwoods) account for most (about 90%) of the timber sales from State Forests. Over the past 20 years the volume of timber sales has averaged around 700,000 cords per year (Figure 3.7). The When considering volume of timber sold for the five major and the ten minor cover types since the mid-1990s, some significant trends can be noted for aspen, northern hardwoods, red pine, white pine and mixed swamp conifers (Tables 3.19 and 3.20). Reflecting the concerted effort prior to the mid-90s to maintain the acreage of the aspen cover type, the number of acres of aspen sold gradually decreased after 1997 and reached a low in 2003. Beginning in the 2004, the acres of aspen sold have

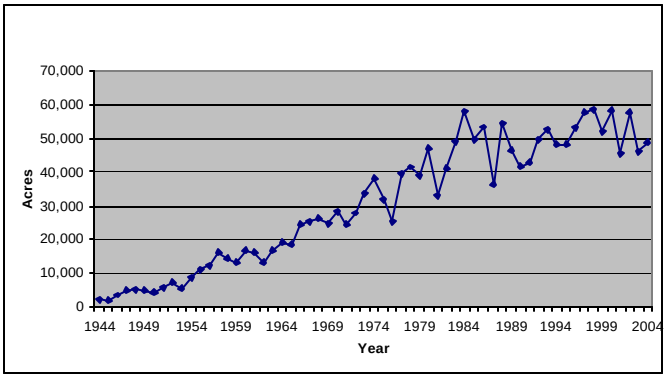

Figure 3.6. Acreage of State Forest timber sold from 1944 to 2004.
(Unpublished DNR Timber Sale Data)

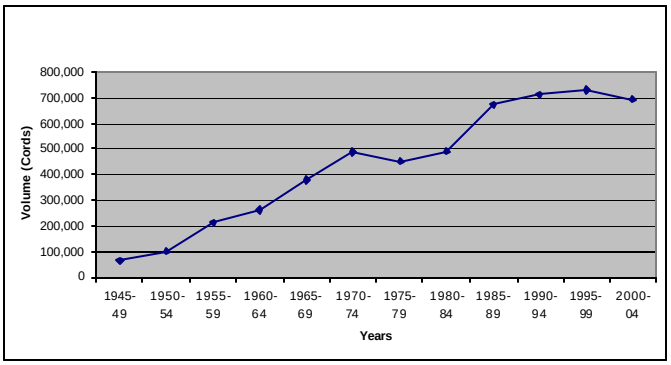

Figure 3.7. Volume of State Forest timber sold (cords) from 1945 to 2004.
(Unpublished DNR Timber Sale Data)

Table 3.19. Volume of timber sales (in cords) of major cover types from 1997 to 2005. (Unpublished DNR Timber Sale Data)

Volume (cords)

FY	Total[1]	Aspen	Jack Pine	N. Hdwds	Oak	Red Pine	Sum of 5 Types	% of Total
1997	766,648	209,230	161,981	132,890	76,192	94,004	674,298	89%
1998	812,514	213,746	136,411	140,151	82,251	139,770	712,328	89%
1999	664,358	182,418	71,931	146,191	90,312	92,368	583,220	90%
2000	747,635	163,069	125,624	162,106	101,472	98,347	650,619	90%
2001	630,376	157,991	90,370	119,063	75,232	97,737	540,394	87%
2002	758,022	154,554	139,690	157,959	94,619	90,863	637,686	85%
2003	640,213	151,222	93,705	142,536	74,163	102,331	563,957	89%
2004	713,710	175,676	120,979	148,413	76,328	97,297	618,693	88%
2005	805,949	203,473	129,911	173,257	74,970	122,727	704,338	88%
Avg	726,603	179,042	118,956	146,952	82,838	103,938	631,726	87%
% of Total:		25%	16%	20%	11%	14%		

Acres

FY	Total[1]	Aspen	Jack Pine	N. Hdwds	Oak	Red Pine	Sum of 5 Types	% of Total
1997	56,972	11,312	11,182	14,319	6,715	7,866	51,394	92%
1998	58,316	10,670	8,591	15,543	7,156	10,297	52,256	91%
1999	52,036	9,246	6,267	15,687	6,958	8,215	46,372	92%
2000	58,241	8,724	9,379	17,979	7,552	8,361	51,994	92%
2001	45,608	7,943	6,094	11,414	6,003	8,022	39,477	88%
2002	57,687	7,847	11,267	16,090	7,377	7,109	49,690	87%
2003	46,318	7,673	6,216	15,254	4,917	7,050	41,110	90%
2004	49,057	9,119	8,246	13,492	6,540	7,170	44,565	92%
2005	55,606	10,064	8,776	15,990	6,638	8,257	49,726	90%
Avg	53,316	9,177	8,446	15,085	6,651	8,039	47,398	89%
% of Total:		17%	16%	28%	12%	15%		

Volume/Acre (cords/acre)

FY	Total[1]	Aspen	Jack Pine	N. Hdwds	Oak	Red Pine	Sum of 5 Types
1997	13.5	18.5	14.5	9.3	11.3	12.0	13.1
1998	13.9	20.0	15.9	9.0	11.5	13.6	13.6
1999	12.8	19.7	11.5	9.3	13.0	11.2	12.6
2000	12.8	18.7	13.4	9.0	13.4	11.8	12.5
2001	13.8	19.9	14.8	10.4	12.5	12.2	13.7
2002	13.1	19.7	12.4	9.8	12.8	12.8	12.8
2003	13.8	19.7	15.1	9.3	15.1	14.5	13.7
2004	14.5	19.3	14.7	11.0	11.7	13.6	13.9
2005	14.5	20.2	14.8	10.8	11.3	14.9	14.2
Avg	13.6	19.5	14.1	9.7	12.5	12.9	13.3

[1] Total of all major and minor cover types

Table 3.20. Volume of timber sales (in cords) of minor cover types from 1997 to 2005. (Unpublished DNR Timber Sale Data)

Volume (cords)

FY	Total[1]	Not Coded	Paper Birch	Cedar	Swamp Hrdwds	Spruce Fir	Hemlock	Lowlnd Poplr	Mxd Swmp Cnfr	Black Spruce	Tamarack	White Pine
1997	766,648	12,718	11,565	1,616	6,829	14,176	3,792	15,664	12,853	2,848		9,394
1998	812,514	9,906	20,930	2,063	6,494	10,491	1,056	10,452	19,315	3,885	427	14,617
1999	664,358	14,963	14,959	945	10,096	7,317		7,065	14,306	353		9,912
2000	747,635	22,333	13,224	991	5,741	8,691	1,775	11,110	15,118	2,871		13,681
2001	630,376	10,847	11,370	2,562	10,139	11,176	2,330	10,601	7,135	7,059	445	15,569
2002	758,022	8,193	17,640	1,683	13,814	21,083	817	31,748	5,362	957	1,424	17,078
2003	640,213	7,731	13,279	484	10,946	12,613	1,148	9,099	7,308	2,924	429	9,016
2004	713,710	7,014	9,968	616	6,649	9,474	1,225	4,566	3,003	3,294	2,116	15,453
2005	805,949	3,545	13,420	940	8,241	11,383	438	10,918	5,762	8,451	2,737	11,746
Avg	727,111	10,805	14,040	1,322	8,772	11,822	1,572	12,358	10,018	3,627	1,263	12,941

Acres

FY	Total[1]	Not Coded	Paper Birch	Cedar	Swamp Hrdwds	Spruce Fir	Hemlock	Lowlnd Poplr	Mxd Swmp Cnfr	Black Spruce	Tamarack	White Pine
1997	56,972	1,280	717	96	445	768	222	839	249	199		692
1998	58,316	842	1,268	105	361	720	95	574	324	248	22	1,340
1999	52,036	1,451	1,081	65	780	474		412	305	145		772
2000	58,241	1,541	744	74	383	604	104	739	296	242		1,267
2001	45,608	812	651	197	800	582	164	710	383	500	19	1,244
2002	57,687	743	832	152	1,005	1,248	100	1,789	363	78	93	1,491
2003	46,318	470	675	27	710	781	125	534	491	202	49	704
2004	49,057	435	537	68	427	586	90	303	198	204	169	1,100
2005	55,606	432	767	61	691	720	29	639	362	591	194	783
Avg	53,178	890	808	94	622	720	116	727	330	268	91	1,044

Volume/Acre

FY	Total[1]	Not Coded	Paper Birch	Cedar	Swamp Hrdwds	Spruce Fir	Hemlock	Lowlnd Poplr	Mxd Swmp Cnfr	Black Spruce	Tamarack	White Pine
1997	13.5	9.9	16.1	16.9	15.3	18.4	17.1	18.7	51.6	14.3		13.6
1998	13.9	11.8	16.5	19.7	18.0	14.6	11.1	18.2	59.7	15.7	19.4	10.9
1999	12.8	10.3	13.8	14.5	12.9	15.4		17.1	47.0	2.4		12.8
2000	12.8	14.5	17.8	13.3	15.0	14.4	17.0	15.0	51.1	11.9		10.8
2001	13.8	13.4	17.5	13.0	12.7	19.2	14.2	14.9	18.6	14.1	23.4	12.5
2002	13.1	11.0	21.2	11.1	13.8	16.9	8.2	17.7	14.8	12.3	15.4	11.5
2003	13.8	16.5	19.7	17.7	15.4	16.2	9.2	17.0	14.9	14.5	8.8	12.8
2004	14.5	16.1	18.6	9.1	15.6	16.2	13.6	15.1	15.2	16.1	12.5	14.0
2005	14.5	8.2	17.5	15.5	11.9	15.8	15.1	17.1	15.9	14.3	14.1	15.0
Avg	13.7	12.1	17.4	14.1	14.1	16.4	13.6	17.0	30.4	13.6	13.9	12.4

[1] Total of all major and minor cover types

started to trend upward again. Throughout this period, aspen volumes per acre remained steady at close to 20 cords per acre. Volume of production from northern hardwoods, red pine and white pine cover types have been increasing since 1996, reflecting the increasing maturation of these cover types. In contrast, production from mixed swamp conifers has dropped off sharply beginning in 2001, in part reflecting changes in coding.

DNR timber harvest trends differ by species. In the past decade, the acres of Michigan State Forest timber sales have leveled off at an average of around 52,000 acres (Table 3.19), and the composition of these sales have changed. More acres of upland hardwood were sold as the number of aspen acres declined. This tradeoff resulted in the loss of some volume and increased labor requirements due to increased selective cutting (single-tree marking in the place of clearcuts). The following discussion of specific cover types focuses upon harvest level trends for different cover types over the coming decade.

Aspen: In comparison to the period of the 1960s to mid-1990s, there were less than half as many aspen acres that met commercial criteria for harvest in the past decade. Past DNR management of aspen has created a very large difference between the number of acres in the current 0-9 age class (86,986) and the 10-19 age class (195,327) (Appendix H). It will be another five to fifteen years before a large number of aspen acres recover to commercially desirable ages. When again available for harvests the DNR will need to work to balance the age class distribution of the aspen cover type. In order to avoid an even more skewed age class distribution and to assure long-term sustainability of the resource, sales of aspen need to increase in certain age classes. Younger stands in the 30 to 49 year age classes should be considered for prescriptive treatment on appropriate sites. In general, the 70 to 89 year age classes should also be prescribed for treatment or they will convert to later successional forest types.

Given the number of acres in the older age (>80 years) classes, it is likely that acres of aspen will slightly decline. Assuming conversions drop the total acreage down towards 850,000 that would still leave 170,000 acres as the area regulation decade sum for five age classes or 17,000 acres annually. Annual aspen sales have averaged 9,177 acres since 1997, but they were generally falling over the period from 1997 to 2005 (Table 3.19). This should be reversed soon, with an emphasis on the balancing of age classes, rather than waiting for the next cohort in the age class structure to reach commercial maturity over the next ten to twenty years. In two to four decades, when the DNR has a large acreage of rotation-aged aspen, a closer examination at landscape, regional and state-wide scales is warranted to determine the appropriateness of maintaining the aspen cover type upon landforms where it is not well suited.

Jack Pine: An accelerated rate of jack pine harvest has been necessary over the past two decades in order to avoid excessive mortality due to jack pine budworm infestations in over-mature stands, which were facing mortality and conversion to other forest types. The accelerated harvesting has resulted in a skewed age class distribution towards the 0-9 and 10-19 year age classes (Appendix H). This bias towards younger age classes is also accentuated in part by Kirtland's Warbler (KW) habitat work which requires shorter rotations. Between efforts to reduce acres in older age classes and the continuing KW work, higher levels of harvests may be maintained

for a few more years or even up to a decade. However, given the age structure of jack pine overall timber sale harvests are expected to decline by 25% to 50% from their recent sales average of 8,446 acres (Table 3.19) for a period starting in the coming decade and lasting for at least three decades. This is simply because the age classes approaching commercial readiness for the next three decades are less than 40,000 acres each, or less than half the average amount which has been harvested in recent years. Even the current 60-69 year age class has less than 40,000 acres.

Northern Hardwoods: Average northern hardwood sales for 1997 through 2005 have been 15,085 acres (Table 3.19). One possible source of an increase in acres would be for the DNR to operate outside of the 10-year compartment review cycle. The current process focuses attention on a particular year-of-entry (approximately one-tenth of the State Forest) rather than the entire forest. This tends to put upland hardwood stands on a twenty-year selection cut harvest schedule as the amount of growth in ten years is usually inadequate for a commercial sale. However, the additional basal area gained may be adequate at some time in the intervening years. To optimally time harvests with variable growth rates, the DNR would have to conduct inventory, prepare sales, and monitor much of the forest on a continual basis, rather than on the current 10-year cycle. The DNR does not have the resources that would enable a shift to a continual management cycle in the near-term, nor would it be necessarily desirable to do so, but with the advent of new plans and software tools such a shift may be possible in the future.

Red Pine: To be balanced over the extent of its current acreage, the distribution of red pine should be at approximately 27,000 acres per age class. Between 1997 and 2005 an average of 8,039 acres of red pine were annually sold (Table 3.19). To date, most red pine harvests (approximately 80%) have entailed thinning stands rather than stand regeneration harvests. Thinning cuts tend to occur every 10-15 years, depending upon site quality and stand condition. Regeneration harvests generally occur between 60 and 90 years of age. Markets are currently best for utility pole-size stands, and the highest returns are on fourteen to sixteen inch trees. Bid values decline for larger size classes. Large acres of red pine are at or approaching the optimal 60-90-year age for regeneration harvest, and although the number of treated red pine acres may not increase during the next decade there should be a transition to more regeneration harvests. Thinning treatments will continue to outnumber regeneration harvests, but the ratio will fall from the current ratio of more than 8 to 1. Management guidelines for red pine have been in existence for several years, and increases in prescriptions for red pine regeneration harvests are beginning to occur. From an average of less than 700 acres for the previous decade regeneration harvests reached 1,552 acres in 2005 and were 1,136 acres in 2006. Regeneration harvests should increase by an average of 10% to 20% and double outputs to over 2,000 acres per year during the next decade. Volume outputs will increase as regeneration cuts provide two to four times the volume of thinning cuts. Increased level of harvests should continue for several decades, until a more balanced age class distribution of red pine is achieved.

Oak: Sales of oak have averaged 6,651 acres from 1997 to 2005 (Table 3.19). Increased timber treatments within the oak cover type are likely, due to the concentration of acres in the 70-100 year range (Appendix H), and an increased understanding and acceptance of maintaining oak as a mixed pine-oak cover type. Most of these treatments will be with higher volume regeneration harvests. For the time being, however, the direction of oak harvests is not certain. Harvests are not

likely to decline in the near-term. Over the long-term (three or more decades from now), oak harvests are likely to decline as the number of acres decline and the species is more integrated with other species. Future opportunities to increase acres of oak also exist, but both resource professionals and the public need to understand and accept the fact that it will mostly exist as part of a mixed pine-oak cover type. To enhance the health and maintenance of the oak component for hard mast production in the State Forest, prescriptive treatments should no longer be delayed to the next decade.

No minor forest cover type shown in Table 3.20 averages more than two percent of sales during the past decade and seldom does any other type reach 3 percent of the sales for any given year. There are many fewer acres of these forest types, and the average acres sold should be put within the context of current total State Forest sales of around 50,000 acres per year. A brief discussion of these minor cover types follows.

Paper Birch: Annual sales of paper birch have remained low, averaging around 800 acres (Table 3.20). This is consistent with its overall decline in total acres for this type.

Hemlock: Acres of hemlock sales have averaged around one-hundred acres per year (Table 3.20), with nearly all of the treatments being selection and shelterwood preparation cuts aimed at promoting regeneration of the species. These actions are consistent with a growing emphasis on restoring the mesic conifer component to many areas of the State Forest. The sale of hemlock as a significant commercial species is not probable for the foreseeable future.

Lowland Hardwoods and Balsam Poplar: Lowland forest types have more factors that limit treatment on a greater number of acres than do upland types. These limiting factors range from access issues, best management practice concerns and environmental issues, through wildlife concerns, markets and regeneration issues. However, a need exists to adjust the harvest of balsam poplar stands with a goal of balancing the age class distribution of this cover type. A similar need exists to even out the age class distribution of lowland hardwoods, as well as to address the issue of excessive mortality within this cover type. Over the past decade an average of 622 acres of lowland hardwoods and 727 acres of balsam poplar were harvested per year (Table 3.20). It is expected that these acreages may increase for each type over the next decade. An exception to this is harvests in riparian zones which will be limited due to beaver management efforts and for the maintenance of habitat connectivity.

Spruce-Fir: Sales of the spruce-fir cover type have averaged 720 acres per year as of 2005 (Table 3.20). Sales of this type are not anticipated to greatly increase due to a greater emphasis on increasing structural diversity of mesic conifers in community types such as northern hardwoods.

Cedar and Tamarack: Acres of cedar sales have declined to around 60 acres per year (Table 3.20) and will likely continue to do so, reflecting regeneration concerns for the species. Acres of tamarack sales have likewise been low at less than 200 acres per year. It is anticipated that sales of both cedar and tamarack will be statistically insignificant for the foreseeable future.

Mixed Swamp Conifers and Black Spruce: Combined sales for mixed swamp conifers and black spruce have averaged close to 600 acres per year (Table 3.20), but

have been trending slightly upward. A large increase in prescriptions within these lowland conifers is less likely than lowland hardwood cover types due to increased concern for the maintenance of wildlife habitat. Expansion of DNR activity in these types will receive extensive scrutiny by a wide array of interests and will need to be done in a very measured fashion. An aggressive effort will need to be made to develop criteria and standards to determine where and how it is viable to operate in these types.

White Pine: There is potential for increased sales of white pine over the next seven decades, as many plantation stands approach a rotational age of 100 years. Over the past decade sales of white pine averaged 1,100 acres per year (Table 3.20). As it becomes an increasing component in mixed aspen, red pine and oak stands the potential production of white pine may become even greater in the future. Increased prescriptions within these minor forest types are not likely to elevate them to the level of prominence accorded to the major timber types at any time in the immediate future. Only modest increases in harvests will likely be experienced with some of these types, most notably for lowland hardwoods, balsam poplar, mixed swamp conifers and black spruce.

3.2 - Forest Health Conditions and Trends

Michigan faces several major forest health concerns. The introduction of non-native plant and animal species and diseases are a serious threat to the health of the State's forest ecosystems, and can have major ecological consequences for the composition of native forest communities. Some epidemic pathogens such as Dutch elm disease, the emerald ash borer and beech bark disease pose threats across the entire landscape of the state. Others are more localized in the range of their impact. The current management strategy is to contain and eradicate newly identified pathogens, however some agents are now securely entrenched into ecosystems of the state. Some pathogenic agents are native to the state and cause infestations that are cyclical in nature. A general discussion of the more significant threats follows below.

Emerald Ash Borer

The introduction of the emerald ash borer (*Agrilis planipennis*) (EAB), a native of China, Korea, Japan, and far eastern Russia, is threatening Michigan's ash resource. All varieties of ash trees appear susceptible. Evidence suggests that the insect has been active in Michigan since at least 1997. The small, green metallic beetles have infested or killed 15 million trees in 21 counties in Southeast Michigan, and there are outlying infestations in 31 other areas of the state (Figure 3.8). All counties in the Lower Peninsula are either quarantined or regulated. No hardwood firewood or ash tree parts or products can move from quarantined areas or out of the Lower Peninsula without MDA inspection and approval.

The discovery of remote, outlying EAB populations continues in Michigan. These outliers mostly represent pre-quarantine (e.g. year 2002 and earlier) spread of EAB. New EAB detections are the result of statewide trap tree surveys by the Michigan Department of Agriculture (MDA) and Michigan Technological University (MTU). The MTU survey is sponsored by the USDA Forest Service. Many of the new 2005 detections resulted from the MTU risk based survey. Risk was defined using maps of the state's ash resources and state park databases showing visits from residents of EAB infested counties. Trap trees were

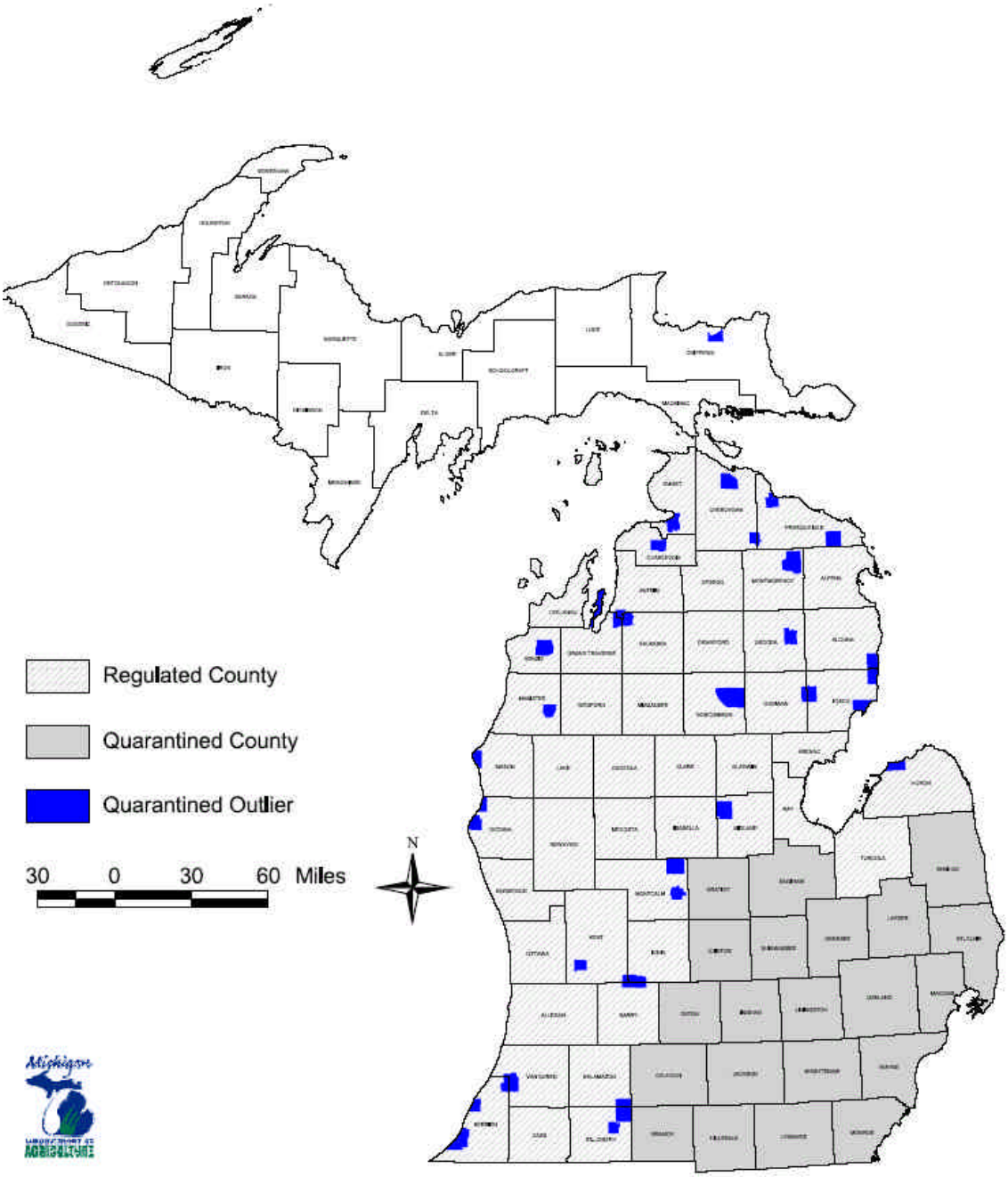

Figure 3.8. Quarantined counties in Michigan with emerald ash borer populations in 2005. (Unpublished DNR Data)

deployed in 135 high risk state and federal parks and campgrounds throughout Michigan and northern Wisconsin. The survey effort also included visual inspections of firewood and ash trees in these and adjacent areas.

The 2005 EAB detection at Brimley was the first in Michigan's Upper Peninsula. The MDA and DNR acted quickly to remove this population. This was a 2002 introduction at Brimley State Park. It does not reflect on quarantine efforts to stop EAB at the Mackinac Bridge or DNR efforts banning the movement of ash onto state and federal lands, both of which began in 2005. No other EAB outliers have been detected in the Upper Peninsula.

The continuing spread of the emerald ash borer infestation portends a future decline of ash resources.

Beech Bark Disease

Beech Bark Disease (BBD) continues to threaten Michigan's American beech resource. Beech is a component in 6.3 million acres of the Maple-Beech-Birch forest type. This represents 138 million beech trees in all size classes. Of these, 15 million larger beech (greater than 9-inch diameter) are highly vulnerable to tree mortality. The disease is caused by the interaction of an exotic scale insect (*Cryptococcus fagisuga*) and a native and exotic canker-causing fungus (*Nectria spp.*). Once infected by the fungus, trees usually decline and trunks may break at canker sites. BBD is presently killing beech trees in areas infested with beech scale for 10 years or more. Many hundreds of acres of American beech are being harvested in the killing front areas of the eastern Upper Peninsula.

The scale infestation is currently concentrated in two primary epicenters, Luce County in the Upper Peninsula and Mason County in the Lower Peninsula (Figure 3.9). The University of Michigan continues to expand the Beech Bark Disease Monitoring & Impact Analysis System (BBDMIAS) plot network. Data collected for the BBDMIAS and also field observations during summer 2005 revealed new beech scale infestations in several areas. Counties in the Lower Peninsula that had new or increasing infestations include Antrim, Emmet, Leelanau, Manistee, Newaygo, Otsego and Wexford Counties. In addition, field crews observed very light scale populations in Cheboygan County and on Bois Blanc Island.

Using data from the BBDMIAS, an effort was begun in 2004 to calculate the current and projected spread of beech bark disease in Michigan. The goal is to develop a model based on empirical data to predict how rapidly beech scale and beech bark disease will spread through Michigan and to determine if spread rates in Michigan are consistent with estimates from other regions of North America. To date it appears the spread rate of beech scale in Michigan is about double that published for the Northeast, or about 10-15 miles per year. Spread rates will vary from stand to stand since the beech resource in the Lower Peninsula is much more fragmented than the Upper Peninsula. The beech scale in the Upper Peninsula was already widely distributed before the initial detection in 2000. Most of Chippewa, Luce and Mackinac Counties are now included in the advancing front and several new areas of infestation were found west of the previous boundary, primarily in Schoolcraft and Alger Counties. Beech trees in a plot on Drummond Island were reported as having light scale but this has not been confirmed.

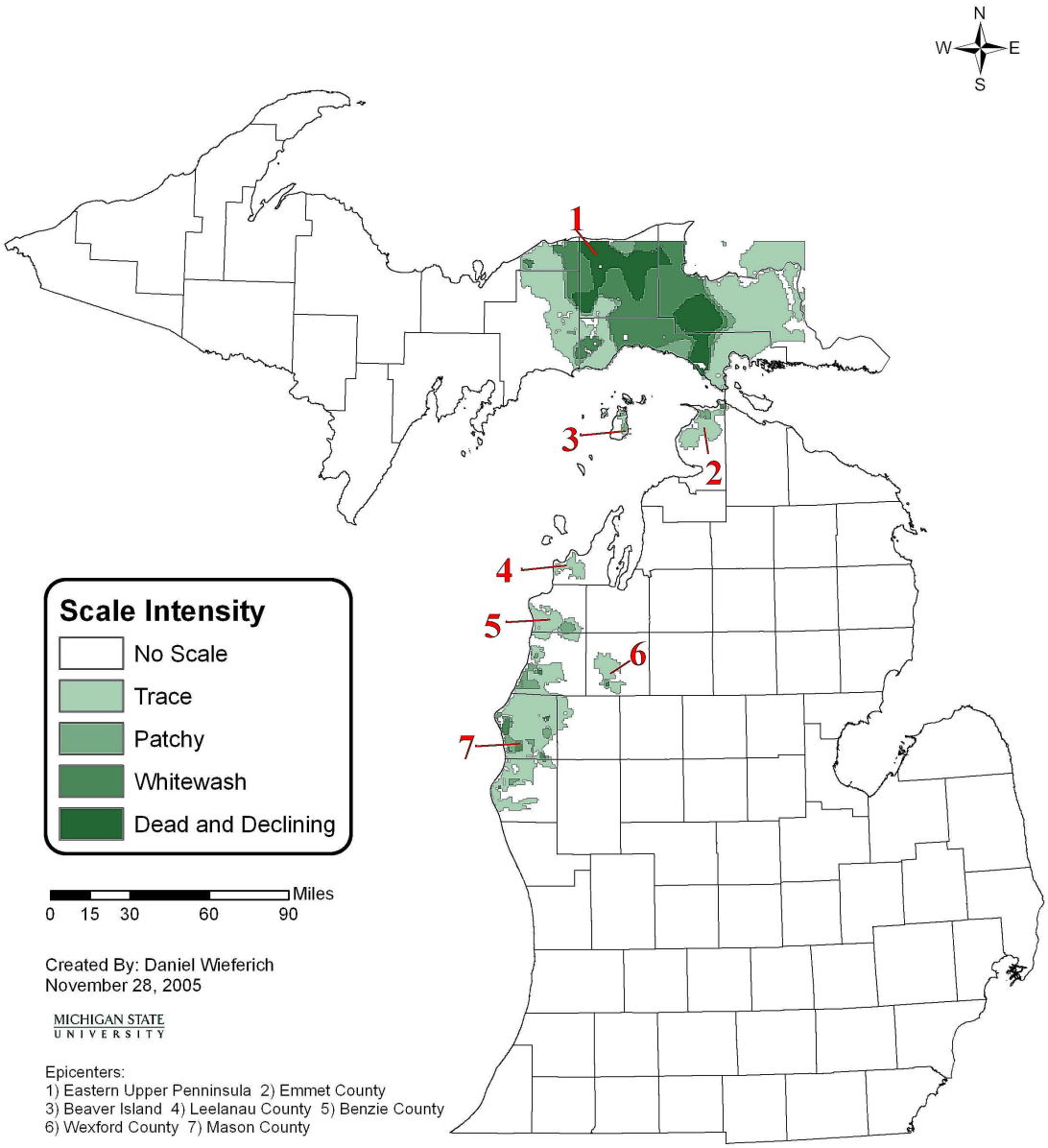

Figure 3.9. Extent of Beech Bark Disease in Michigan in 2005.
(Unpublished DNR Data)

Mortality did not increase as dramatically as scale populations and most areas are still in the early stages of scale infestation. The most dramatic increase in beech mortality was in Tahquamenon Falls State Park on the Chippewa/Luce County border where over 90% of the beech overstory is either dead or severely declining.

The USDA Forest Service Research Facility in Delaware, Ohio continues to collect scions from resistant trees in Michigan to study BBD resistance. Scions from resistant American beech were again collected in December, 2005 and sent to the Delaware, OH USFS research facility. Michigan has also agreed to host 1 or 2 seed orchards for propagating resistant seed beginning in the fall, 2006.

Eastern Larch Beetle

Eastern larch beetle (*Dendroctonus simplex)*, populations in Eastern and the South Central Upper Peninsula caused 25,717 acres of cumulative mortality that began in 2002 (Figure 3.10). This bark beetle became epidemic in tamarack (*Larix laricina*) trees stressed from the drought of 2000-2001 and repeated defoliation by the larch casebearer (*Coleophora laricella*).

The casebearer is an exotic needle-mining insect that was introduced to the Lake States in the early 1900s. Populations are usually brought under control within 2 years by natural parasitic enemies, but repeated heavy defoliation can cause branch dieback or tree mortality.

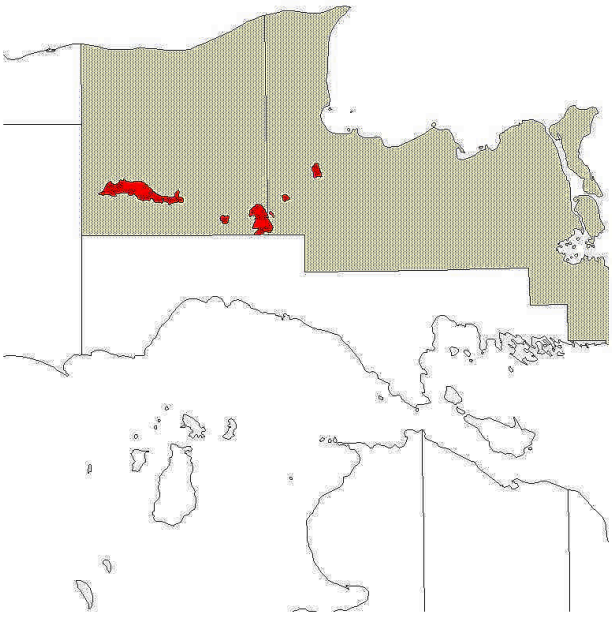

Figure 3.10. Extent of Eastern Larch Beetle in Michigan in 2005.
(Unpublished DNR Data)

Gypsy Moth

Gypsy moth (*Lymantria dispar*) defoliated 148,525 acres of oak forests statewide in 2005, up from 45,244 acres in 2004 (Figure 3.11). A warm, dry spring in 2005 did not favor entomophaga fungal pathogen development, so overall state populations of gypsy moth will likely increase in 2006.

According to a Michigan Department of Agriculture report a total of 4,316 acres in six counties in the Lower Peninsula were treated as part of the Cooperative Gypsy Moth Suppression Program in 2005. This was a significantly smaller acreage than 2004, when 24,581 acres were treated in 11 counties, and represents the second smallest treatment acreage since the program's inception in the 1980's.

Oak Wilt

Oak wilt continues to spread naturally and artificially through much of the Lower Peninsula and in the south central Upper Peninsula (Figure 3.12). Movement of oak wilt on firewood is plaguing efforts to slow the spread of this fatal oak disease. To slow the overland spread of oak wilt, harvesting restrictions are observed on state land. Harvesting activities in forests where red oak trees remain after harvest cannot be cut between April 15 and July 15. Sap-feeding beetles responsible for spreading oak wilt are most active during this time. These small (1/4-inch long) beetles can pick up spores from diseased trees and transmit them to oak trees that have been damaged during logging operations.

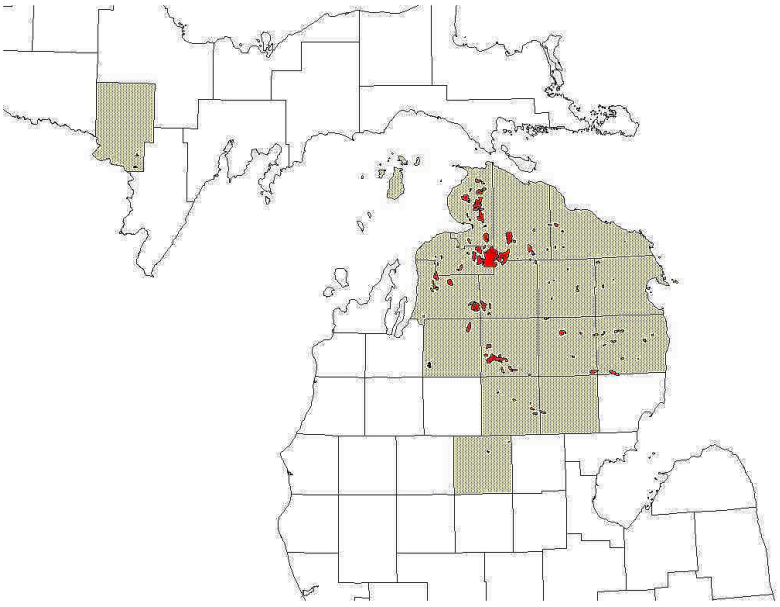

Figure 3.11. Extent of Gypsy Moth in Michigan in 2005.
(Unpublished DNR Data)

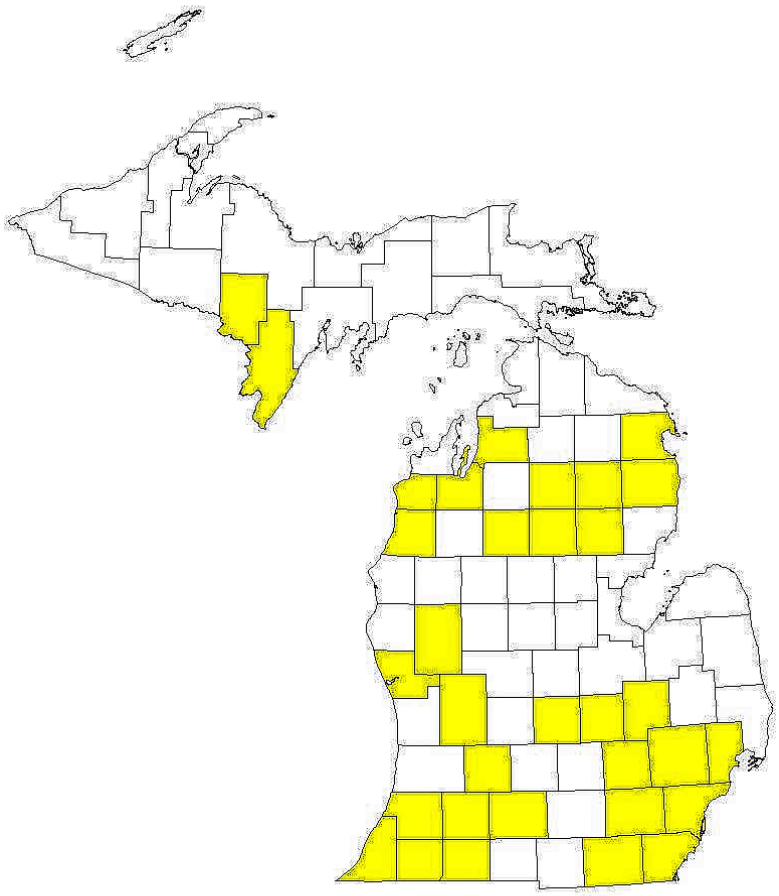

Figure 3.12. Counties in Michigan with oak wilt in 2005.
(Unpublished DNR Data)

US Forest Service oak wilt suppression funds for detecting and treating oak wilt epicenters in Michigan's Upper Peninsula were not available in 2005. However, detection efforts and landowners contacts continued in efforts to rid the Upper Peninsula of this threat to its oak resources.

Red-Headed Pine Sawfly

The red-headed pine sawfly (*Neodiprion lecontei*) periodically defoliates young red and jack pine. Sawfly populations have been active in the eastern Upper Peninsula and the northern Lower Peninsula beginning in 2002. Heaviest infestations are in pines growing under stress, particularly those at the edges of hardwood forests, on poor soils, and where there is heavy competitive vegetation. In general, it infests and damages trees less than 15 feet tall. Moderate to heavy defoliation stunts height growth of infested trees and forking may result from top kill. Complete defoliation usually kills the tree. Dimlin 4L was aerially applied to 480 acres of infested plantation red pine in 2005.

Jack Pine Budworm

The jack pine budworm (*Choristoneura pinus pinus)* is considered the most significant pest of jack pine. Stands older than 50 years are vulnerable to damage. Jack pine over 50 years old that has suffered 2 or more defoliations during the past 3 years is at highest risk of top kill or mortality. Tree mortality and top-kill resulting from budworm defoliation creates fuel for intense wildfires. Harvesting stands when they reach maturity can minimize budworm-caused tree mortality and reduce the threat of damaging wildfires.

The current jack pine budworm epidemic defoliated 201,470 acres this year and has spread to many areas of jack pine in the Upper Peninsula (Figure 3.13). Student assistants were used to assess budworm impacts on high risk stands. Based on these impact surveys many stands are being salvaged and pre-salvaged. Other stands were targeted for 2006 evaluation. High risk stands were also recommended for harvest in the Northern Lower Peninsula based on stand vulnerability, budworm damage and defoliation surveys. Budworm populations in the Lower Peninsula are subsiding.

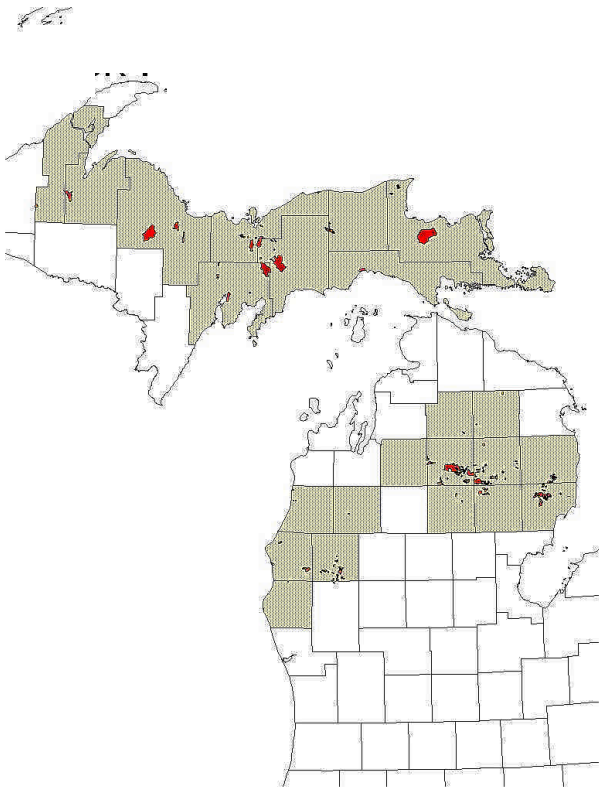

Figure 3.13. Extent of Jack Pine Budworm in Michigan in 2005.
(Unpublished DNR Data)

Spruce Budworm

Spruce budworm defoliated 9471 acres in several counties in Michigan's Upper Peninsula (Figure 3.14). Areas of light budworm defoliation have been visible for the last few years. Areas of mature to over mature spruce/fir in the south central Upper Peninsula (south western Menominee County) have top kill and tree mortality caused by repeated defoliations.

Dutch Elm Disease

The non-native Dutch elm disease continues to cause extensive mortality of American elm within both upland and lowland hardwood communities. It is expected that stocks of American elm will continue to decline throughout the forest landscape.

Forest Tent Caterpillar

Only a few small scattered pockets of aspen and oak defoliation remain as evidence of the large scale Forest Tent Caterpillar (*Malacosoma disstria*) epidemic which began in 2000.

Sudden Oak Death

Sudden oak death (SOD), now known as Ramorum Blight (*Phytophthora* ramorum), has not been detected in Michigan's nurseries, urban forests or forest lands.

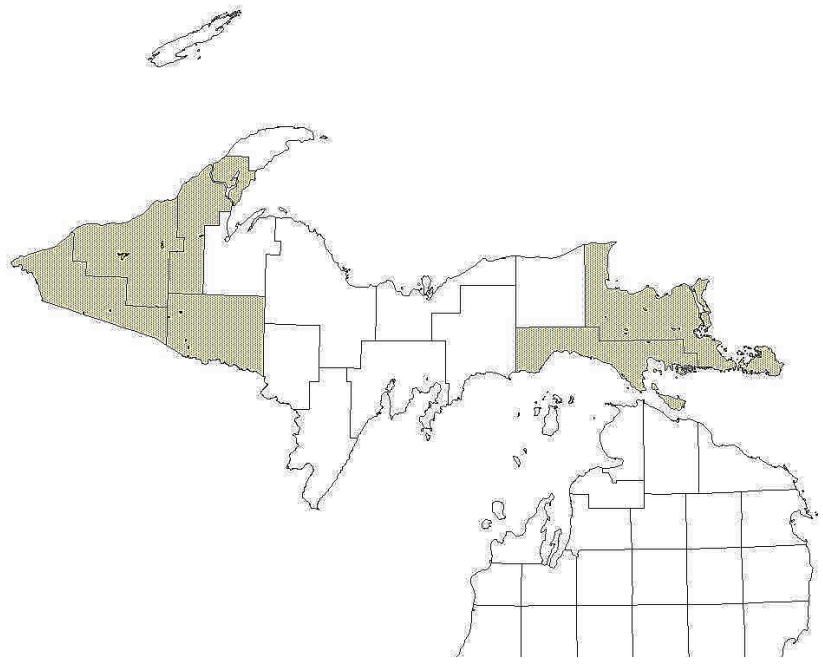

Figure 3.14. Extent of Spruce Budworm in Michigan in 2005.
(Unpublished DNR Data)

Black Ash Decline and Mortality

Black ash decline and mortality continues to be common in many parts of the state. This is related to past drought conditions. Trees growing in wet soils, such as black ash, often suffer during droughts. Wetland trees tend to develop shallow root systems that cannot cope with a prolonged drop in soil moisture. Rising water tables after a prolonged drought may also drown deeper roots developed as the tree sought moisture during the drought years.

White Ash Root Rot

A white ash root rot is causing extensive wind throw of mature ash in high quality northern hardwood stands in Northern Lower Michigan. Stresses from overstocking may be involved. University and USDA Forest Service forest pathologists and entomologists visited ash decline areas in Northern Lower Michigan. Ash yellows was diagnosed as one of the causal agents of decline. Armillaria and other root pathogens are also involved. Further study based on these finding will follow. Understanding ash health is paramount in assessing the susceptibility of ash resources to EAB.

Hemlock Woolly Adelgid

The hemlock woolly adelgid (*Adelges tsugae*) quarantine continues to restrict movement of eastern hemlock into Michigan from infested counties of other states. All eastern hemlock shipments require a phytosanitary certificate. This follows the interception of the insect at two Michigan nurseries in 2000. Hemlock woolly adelgid is dispersed by wind and by movement of infested firewood, and feeds on tree sap, killing needles, twigs and branches. Infested trees eventually die. Rapid early detection surveys for the adelgid were conducted statewide for the fourth straight year in hemlock stands and in areas adjacent to nurseries. This is part of a Forest Health Monitoring Evaluation project. No adelgids were found in 2005.

White Pine Weevil

The white pine weevil (*Pissodes strobe*) is a destructive insect of eastern white pine, jack pine and Norway spruce. The weevil breeds in and destroys the terminal leader of white pine, causing forking and crooking of the tree. In general it prefers open-grown trees from 2 to 20 feet tall, feeding on the previous year's terminal in the spring and on lateral in the summer and fall. Stem deformities may result in wood defects such as compression wood and bark-encased knots that reduce the value of sawn lumber. This reduction in wood quality is considered the major impact of the white pine weevil. Detrimental impacts from the weevil can be avoided though recruitment of white pine through the understory of existing forest stands.

White Pine Blister Rust

White pine blister rust (*Cronartium* ribicola) is the only stem rust of white pines in North America. An apparent native of Asia, blister rust was introduced to eastern North America on eastern white pine (*Pinus strobes*) seedlings from nurseries in Germany in about 1898. Currants and gooseberries in the genus *Ribes* serve as an alternate host for the rust fungus that causes white pine blister rust. Blister rust and the white pine weevil have given eastern white pine a reputation as a difficult species to culture in forest stands, but the evidence of

increasing natural recruitment of white pine provides a convincing counter-argument to the validity of this concern.

Invasive Plant Species

Scots pine (*Pinus sylvestris*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), Spotted Knapweed (*Centaurea maculosa*), garlic mustard (*Alliaria petiolata*), giant hogweed (*Heracleum mantegazzianum)*, cluster head pink (*Dianthus carthusianorum*), phragmites (*Phragmites australis*), and purple loosestrife (*Lythrum salicaria*) are some of the more significant non-native, invasive plants in the Great Lakes region. Giant hogweed has been found in 11 Michigan counties (Figure 3.15). First discovered in 2001, Giant hogweed has now been confirmed in the following counties: Branch, Calhoun, Gogebic, Ingham, Jackson, Kalamazoo, Kent, Manistee, Oakland, Ottawa and Saginaw.

Finding a long-term management solution for invasive plant species may be difficult, as the only recourse for control in many instances is labor intensive removal or herbicide treatment.

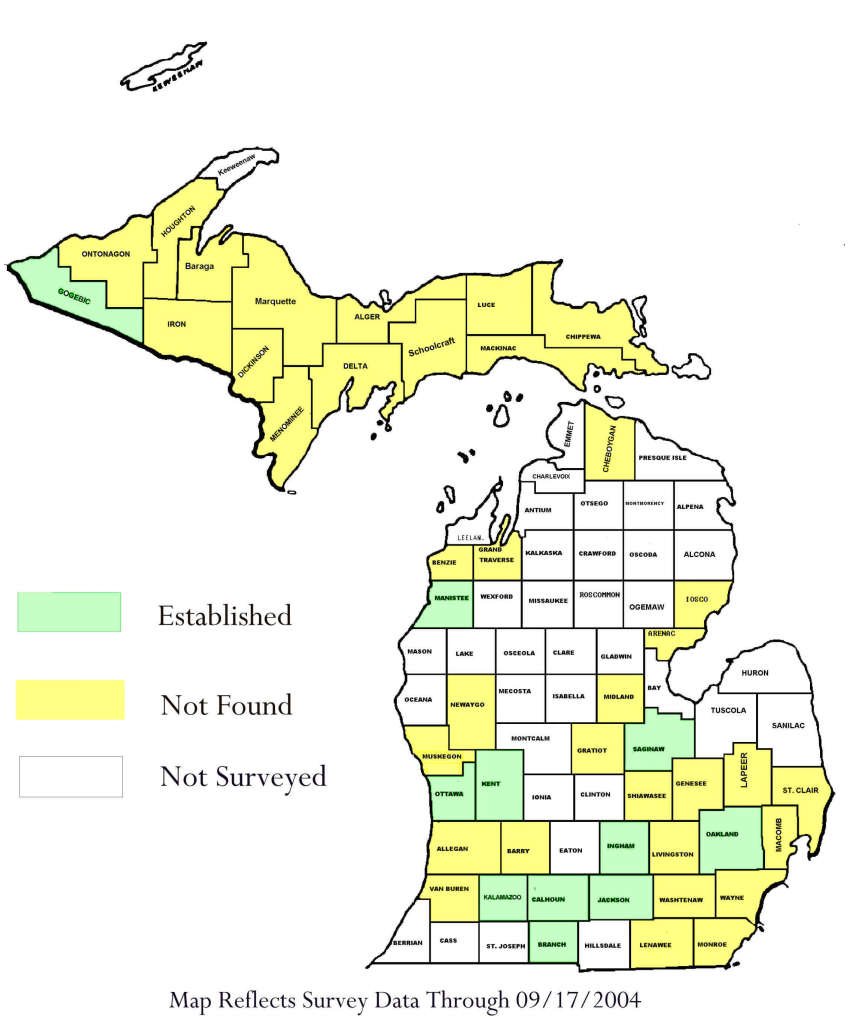

Figure 3.15. Extent of Giant Hogweed in Michigan in 2005. (Unpublished DNR Data)

The establishment of biological control organisms is also one area of interest. Presently, Scots pine is being systematically removed from state forestlands, and prescribed fire is being tried to reduce spotted knapweed populations in oak savannas in the south central Upper Peninsula. Cluster head pink was detected in the Upper Peninsula and efforts to eradicate are planned for 2006. The Seney National Wildlife Refuge continues to battle common buckthorn populations with herbicides and prescribed fire.

Recent successes with the release of two small leaf-feeding beetles on purple loosestrife have reinforced the positive benefits that a successful and carefully implemented biological control program can have. Purple loosestrife populations have declined in many areas where *Galareucella* beetles have been released.

Garlic mustard monitoring, management and eradication projects are gaining momentum in Michigan. Public and private organizations are cooperating in efforts to remove and keep garlic mustard from establishing in new areas of Upper Michigan and the Northwest Lower Peninsula. A seventy acre northern hardwoods site in the Eastern Upper Peninsula has a seven year prescribed burn plan which includes follow-up use of glyphosate herbicide to treat plants missed by fire. Treatments are designed to contain the spread of the plant and eventually eliminate garlic mustard. Additional monitoring of plant community response to burning and herbicide treatments is planned for 2006.

3.3 - Wildlife Habitat Conditions and Trends

Strategies on the conservation of wildlife species continued to evolve in step with the understanding of the tremendous impact that human development has had and continues to have upon the landscape of the state. It is known that the survival of wildlife species is inextricably linked to the habitat that supports them, and that the degradation or loss of habitat is often the primary threat to species viability. Based upon this premise the DNR has developed a Wildlife Action Plan (WAP) with the goal of providing a common strategic framework that will enable Michigan's conservation partners to jointly implement a long-term holistic approach for the conservation of wildlife species. The WAP primarily uses a statewide coarse-filter approach based upon the habitat needs of wildlife to effectively conserve rare, declining and common species, and also provides a fine-filter approach that to address species that may not satisfactorily respond to habitat or ecosystem-based conservation approaches. Using both the species-based fine filter approach in concert with the habitat-based coarse filter approach will provide a more balanced strategy for the conservation of wildlife diversity.

There are currently 947 known vertebrate and invertebrate wildlife species in Michigan. It is estimated that there are an additional 15 to 20 thousand insect species in the State. Rather than discuss individual wildlife species in depth, this section of the plan discusses the major vegetative communities that support wildlife on State Forest land, and the characteristics of those communities that are important to maintain habitats for diverse and sustainable wildlife populations.

3.3.1 - Forested Habitats

The present forested communities of northern Michigan are very different from the pre-European settlement forest. Compared to pre-European settlement forests, today's forests are relatively young and still in the process of recovering from the lumbering era

of the late 1800s. Even so, present forests are now older and have greater diversity and structure than forests of just 50 years ago.
The value and relationship of a forest stand to wildlife is more complex than mere age, and is a function of both the structural attributes of the stand and the landscape mosaic in which the stand is located. Within stand attributes such as vegetative species composition, vertical structure, and ground cover and debris are attributes that wildlife managers attempt to manipulate to improve the value of a stand for wildlife. Attributes of the surrounding landscape mosaic such as habitat connectivity, patch size, and landscape diversity are often just as important as stand age in determining the value for wildlife habitat.

Historically, wildlife evolved to the structural and compositional diversity of forests under conditions dictated by natural disturbance regimes such as fire, windthrow, periodic flooding and disease. These ecological processes have been altered or severely restricted by present management. The primary disturbance factors affecting Michigan's State Forest are commercial timber harvesting, exotic and native forest pests and diseases, recreational activities, road building, and oil and gas development. These disturbance factors result in a young, relatively fragmented forest that favors wildlife adapted to early successional forest types and edge habitats. Habitat needs of interior wildlife populations are best served by forest management practices that mimic the structure and composition of the older, more contiguous pre-European settlement forest.

Evaluating the condition of the major forest types in the state forest system helps clarify some of the major wildlife issues on these lands.

Aspen

The intensive logging associated with European settlement greatly expanded the extent of aspen, and it now covers 885 thousand acres or 22.5% of the State Forest. Aspen will continue to be a major forest type in Michigan as it is in demand both for fiber and as wildlife habitat for the principle game species (ruffed grouse, woodcock, and deer) of northern Michigan. Aspen is also very important habitat to a variety of non-game species such as chestnut-sided warbler and golden-winged warbler. Approximately seventy species of vertebrates use aspen forest as habitat in northern Michigan (Doepker et al. 2001).

Long-term maintenance of aspen as wildlife habitat on state forest land will require a balancing of the age class distribution. A fifty year rotation for aspen harvest benefits those wildlife species that use the earlier age class aspen stands, but consideration must also be given the wildlife habitat values of older aspen stands. Old aspen trees provide a significant amount of large coarse woody debris and snags to the forested landscape.

The value of aspen as wildlife habitat is also dependent on the productivity of the site. Productive sites that produce dense, young aspen stands with a variety of fruiting shrubs provide the best habitat for the greatest variety of aspen-dependent species. Nutrient poor, dry sites often produce less dense and diverse aspen stands with trees in poor health. It may be appropriate to convert these stands to pine types.

Northern Hardwoods

The northern hardwoods cover type is the second-largest acreage on State Forest Land at over 508,000 acres or 13% of the land base. Northern hardwoods provide habitat for approximately 115 wildlife species (Doepker et al. 2001) including the northern flying squirrel and the barred owl.

The value of northern hardwoods to wildlife is largely dependent upon structural and compositional diversity within the stand. The lumbering era and some present management have reduced the conifer component of northern hardwood stands. The Mesic Conifer Initiative in the Western Upper Peninsula ecoregion is partially restoring the conifer component to the northern hardwood forests of this region. Restoration of the conifer component should improve these stands as habitat for species like the blackburnian warbler and white-tailed deer. The current single tree selection method of harvest that is employed in uneven-aged management of this forest type, often reduced tree species diversity by selecting against the retention of low timber value deciduous and coniferous species.

Large contiguous blocks of northern hardwood forest provide important habitat for area sensitive bird species and black bear, and maintaining habitat connectivity in this type is important. To enhance the value of northern hardwoods to wildlife, opportunities to preserve or enhance vegetative and structural diversity to the stand should be taken advantage of. Restoration of diversity in this type includes retention of some trees into older age classes as future den trees, snags, and coarse woody debris.

Northern hardwoods are in the understory of 123,000 acres of existing aspen stands, over 67,000 acres of existing oak stands, and over 44,000 acres of current red pine stands. Active management of aspen for wildlife and fiber values will likely keep many aspen stands from succession to northern hardwoods. The difficulty in regenerating oak and the use of less chemical control of hardwoods on current red pine sites that are more ecologically suited for hardwoods, portends a future State Forest with more northern hardwood acres than currently exist.

Jack Pine

Jack pine is a dominant or associate tree species in several natural communities including interdunal wetland, poor conifer swamp, boreal forest, dry northern forest, oak-pine barrens, pine barrens, and Great Lakes barrens. The acreage of jack pine in the State Forest has been fairly consistent since circa 1800, having only slightly decreased (Table 7). This is not surprising given the large areas of xeric, outwash soil types within the State Forest, to which the species is well adapted and competitive. Jack pine currently covers 367,000 acres (9.3%) of the State Forest, but has declined by 35,000 acres (8.6%) since 1988. Jack Pine provides habitat for Approximately 65 species of vertebrates (Doepker et al. 2001) including the federally endangered Kirtland's Warbler and the State endangered Prairie Warbler.

Jack Pine is the dominant and best represented tree on the driest and least fertile soils in northern Michigan. On glacial outwash plains in the northern Lower Peninsula 92,000 acres of the State Forest are managed within dedicated Kirtland's Warbler management areas. Plantation management using an opposing wave pattern has

contributed to a significant increase in the Kirtland's Warbler population over the last 20 years.

In the absence of stand replacing fire, it is important that even-age management clearcuts leave adequate snags and small openings for wildlife adapted to these habitat features.

Red Pine

Red pine is a dominant or associate tree species in several natural communities including boreal forests, dry-mesic northern forests, dry northern forests, oak barrens, oak-pine barrens, pine barrens, Great Lakes barrens, and bedrock glades. There are currently 280,000 acres of red pine in the State Forest, mostly managed in monoculture plantations. The age class distribution of red pine is heavily skewed to older aged stands. Red pine trees can function as nesting cover for numerous bird species including pine sisken, yellow-rumped warbler and pine warbler. Red Pine also provides habitat for approximately 55 vertebrate species (Doepker et al. 2001).

Circa 1800, there were over 406,000 acres of red pine (predominantly mixed red and white pine associations) in the area of the present State Forest, representing over 10% of the forested land base. Today, red pine dominated natural communities such as dry-mesic northern forests, dry northern forests, and pine barrens are some of the rarest natural communities in the State. Wildlife species adapted to using red pine to fulfill important life requisites are adapted to the structural characteristics of red pine forest in these natural communities. Wildlife habitat values associated with red pine will be enhanced by management activities that restore red pine dominated natural communities. The DNR's Red Pine Project developed guidelines for identifying the best sites on which to restore natural red pine communities and at the same time correct the heavily skewed age-class distribution in existing plantations.

Mixed Swamp Conifers

Mixed swamp conifers comprise over 261,000 acres of the State Forest (6.6%), but the cover type has declined by almost 523,000 acres (60%) since circa 1800. Mixed swamp conifer species (black spruce, cedar, tamarack, balsam fir) are most often associated with the Poor Conifer Swamp natural community. Mixed swamp conifers provide habitat for a variety of wildlife species including black bear, bobcat, moose, and deer. Mixed swamp conifers provide important thermal cover for deer. Mixed swamp conifers also provide habitat for approximately 70 vertebrate wildlife species (Doepker et al. 2001).

Most acreage is in the pole timber size class, which increased by over 12,000 acres since 1988. Corresponding decreases were recorded in the acreage of the seedling-sapling size class. The vast majority of this cover type is older than 70 years on state forest land. The wildlife values associated with the younger age classes are rapidly disappearing, largely due to lack of harvest prescriptions and a concerted effort to reduce the scale and intensity of fire disturbance in the landscape. Lack of confidence in the ability to regenerate this cover type contributes to managerial reluctance to prescribe treatments in this type. While the wildlife values associated with the older

age classes are secure, more research into silvicultural techniques to regenerate this community needs to occur.

Oak

Oak forest covers 244,000 acres of the State Forest (6.2%). Oak species were often a component of naturally mixed pine-oak communities in the circa 1800 landscape of upper Michigan, but was only a relatively minor cover type (72,000 acres or 2%) of what is now the State Forest land base. The present oak-dominated stands that are common on moderate to low quality, sandy soil sites are anomalies which resulted from the logging of the circa 1800 pine forest and the unnatural catastrophic fires that followed. Oak forests now provide habitat for approximately 95 vertebrate wildlife species in northern Michigan including the eastern hognose snake, white-tailed deer, and wild turkeys (Doepker et al. 2001). Oak acorns, along with beechnuts, are the primary sources of hard mast for wildlife in the northern forest.

Approximately half of the oak cover type in the State Forest is succeeding to other types. Maintenance of this cover type at its current level is not possible without replicating the events of the past – which will certainly not occur, or developing silvicultural techniques that are more reliable at regenerating oak. Land managers are currently faced with a dilemma: is it better to continue to retain oak in the 70 -100 year age class for its mast producing capability today, knowing that it will eventually die and succeed to other types; or is it more prudent to cut mature oak and aggressively experiment with different methods to regenerate oak. Developing the capability to successfully regenerate oak in the northern forests of Michigan is critical to maintaining healthy populations of some of the most popular game species on State Forest lands.

Cedar Swamp

Cedar swamps are present on 228,000 acres of State Forest (5.8%). This acreage is fairly consistent with the circa 1800 acreage of 219,000 acres. Cedar swamps are most often associated with the Rich Conifer Swamp natural community. Cedar swamps provide habitat for a variety of wildlife species including snowshoe hare, bobcat, elk, and deer. Cedar swamps are critical winter habitat for deer in the Upper Peninsula, providing both thermal cover and food. Cedar swamps also provide habitat for approximately 50 vertebrate wildlife species (Doepker et al. 2001).

Most of the acreage of cedar swamp lies in the well stocked pole timber size class with an age class distribution that is highly skewed. More than 80% of cedar swamps are over 80 years old with the 100+ age class predominating. Cedar swamps over 80 years old were able to regenerate during a period of relatively low deer populations immediately following the peak of the lumbering era and the subsequent landscape level fires that followed (Pregitzer 1990). With a relatively young forest as compared to circa 1800 forest, the present summer range supports higher populations of deer. These deer are concentrated into a limited acreage of winter cover, severely restricting the ability to regenerate cedar swamps.

The inability to successfully regenerate cedar, combined with the preponderance of other conifers and lowland hardwoods in the understory of the cedar type will likely lead to a State Forest with less cedar in the landscape and lower populations of those wildlife species dependant upon cedar swamps

White Pine

White Pine-dominated forests cover approximately 94,000 acres of State Forest, which is a 68% increase since 1968. White pine is a dominant or associate tree species in several natural communities including boreal forests, dry-mesic northern forests, dry northern forests, mesic northern forests, oak-pine barrens, pine barrens, Great Lakes barrens, and bedrock glades. White pine provides habitat for Approximately 55 species of wildlife (Doepker et al. 2001), including the bald eagle (state threatened), and the merlin (state threatened).

White pine trees are often wind-firm and individuals can be left as legacy trees. Super canopy and legacy trees are often used by raptors as perches and preferred by nesting bald eagles and osprey when they are located near bodies of water. Large mature trees with broken tops provide valuable habitat for cavity nesting wildlife. Fallen tops can provide cover for a variety of species, including snow-shoe hare. White pines have sturdy, creviced bark that black bear cubs can easily climb to escape danger and because of this are considered the preferred escape tree. Female bears will take their cubs year after year to the same tree. In addition, black bears will make dens under the root mass of uprooted trees.

Mesic conifers, such as white pine, red pine, and hemlock commonly occurred in circa 1800 mixed conifer forest. These forest types are some of the rarest in the State Forest system. The mesic conifer initiative in the Western Upper Peninsula ecoregion has a goal to increase both the mesic conifer component in deciduous forest types and the amount of mixed conifer upland forest.
As is being encouraged (and reflected in the understory data) natural regeneration of white pine is increasing in many forest types (particularly oak, aspen and red pine) in the State Forest system. For the foreseeable future, wildlife species dependent upon mixed pine and pine/hardwood communities will have significantly more habitat than presently exists.

Hemlock

Hemlock was historically present in 345,000 acres of the State Forest land base in the form of hemlock-white pine and hemlock-yellow birch associations. Hemlock was also a co-dominant component in the northern hardwoods cover type. Today, hemlock stands comprise just over 17,000 acres of the current DNR land base, and it is the least represented of any native tree species. Eastern hemlock is a dominant or associate tree species in several natural communities including mesic northern forests, dry-mesic northern forests, and hardwood-conifer swamps. Hemlock provides habitat for 69 species of wildlife (Doepker et al. 2001) including the red-shouldered hawk and the northern goshawk.

Hemlock serves as an important source of thermal cover for white-tailed deer and moose. The historical value of hemlock as stands, groups of trees, and individual trees is well documented in this regard. It provides cover for porcupines, fisher, and marten, as well as nesting cavities for woodpeckers, flickers, and red squirrels. Hemlock is a long-lived species (600+ years), and individuals can be left as legacy trees to provide perches and cavities. Large over-mature trees eventually blow down, providing coarse woody debris on the forest floor which has value for foraging predators, amphibians, and forest regeneration as nurse logs.

Unlike white pine, the conditions required to successfully regenerate hemlock are not occurring naturally. There has been very little hemlock regeneration over the past century, with most remaining hemlock in the 100+ year and uneven aged classes. Successful regeneration of hemlock requires multiple favorable conditions, adding to the imperative of retaining seed trees. Under planting of hemlock is often required to return hemlock as a component of the landscape. The mesic conifer initiative is a useful tool to help expand the hemlock component within other forest types across the entire state forest system.

3.3.2 - Grasslands

Grasslands are present upon 125,000 acres of the current State Forest, but have declined by 52,000 acres since 1988. This is still many times the historic acreage of less than 4,000 acres. Almost half (60,147 acres) of all state forest grasslands are located in the Northern Lower Peninsula ecoregion. A significant acreage of grasslands is located in the Eastern Upper Peninsula ecoregion, with almost 42,000 acres or 33.5% of the cover type. There is a much smaller acreage of grassland in the Western Upper Peninsula ecoregion, with 23,146 acres (18.5%). Wildlife species associated with grasslands have experienced some of the greatest declines in population levels (Herkert 1995).

Grasslands on the State Forest system fall into 3 broad categories. These categories are: maintained wildlife openings; natural grasslands that are part of barren or savanna communities; and old field grasslands. Maintained wildlife openings are actively managed openings within the forested landscape designed to enhance habitat components for wildlife. Most of these openings were created to provide herbaceous forage for deer and elk.

Native grasslands that are part of barrens or savanna were historically maintained by fire disturbance. The suppression of fire in these landscapes has allowed trees to encroach on these grasslands. Restoration of these native grassland systems using prescribed fire is a key method of improving grassland wildlife habitat on State Forest lands.

3.3.3 - Wetlands

Wetlands on the state forest system fall into 2 major cover types, forested wetlands and non-forested wetlands. Forested types include the cedar swamps and lowland hardwoods already discussed, but also include tamarack swamps and treed bogs. Non-forested types include bogs, fens, emergent marshes, and scrub-carr wetlands. The non-forested wetlands are some of the least managed vegetation types on State Forest land except where they were created by the damming of streams and are managed as wildlife floodings.

Wetlands are some of the most productive environments for a wide variety of wildlife species. Ephemeral wetlands such as vernal ponds within upland forest are critical breeding habitat for amphibians and also provide some of the earliest green vegetation in the spring for black bears. Generally, the amount of wetlands on state forest lands has remained the same between 1988 and 2006.

Wildlife habitat values associated with wetlands are generally best preserved or enhanced by maintaining or restoring natural hydrological regimes in the wetland, and maintaining or enhancing structural characteristics by leaving adequate snags and downed woody debris when managing forested wetland cover types.

3.4 - Water and Fisheries Conditions and Trends

Michigan is responsible for stewardship of 43% of the Laurentian Great Lakes, which hold over 20% of the world's fresh water. The Great Lakes have extensive, diverse, and productive coastal wetland complexes along shorelines and at river mouths. These wetlands serve as spawning and nursery grounds for many Great Lakes fishes, and as feeding grounds for both fishes and water birds.

Extensive wetland ecosystems are supported inland by the humid and cool climate combined with widely distributed porous soils. Diverse hydrologic and geomorphic landscape settings provide an array of wetland types, supporting diverse and productive biological assemblages. Wetlands in northern Michigan are typified by strong groundwater sources and northern vegetative and animal species. Many wetlands are found at the interface of lakes, rivers and streams, and provide important ecological services to those systems as sources of high quality water and aquatic wildlife habitat.

Michigan contains over 10,000 lakes and 32,000 miles of rivers and streams that support a diversity of aquatic communities and fisheries typical of the range commonly found across northern North America. The forested landscapes of northern Michigan contain approximately half of these lakes, including a number of very large, often deep lakes (54 lakes greater than 1000 acres and up to 290 ft in depth). Due to colder climates, substantial groundwater inflows, drainage of unproductive soils, and often significant depths, many of these northern lakes are classified as oligotrophic (clear, cool or cold waters, relatively low levels of nutrients and plenty of oxygen for fish in the deeper waters), or mesotrophic (cool waters with moderate nutrients). These lakes support assemblages of aquatic plants and animals common to cold or cool waters in northern North America.

Northern Michigan is home to 49% of the state's stream mileage. About 39% of northern streams and rivers drain hilly and porous landscapes, receive abundant groundwater inputs, and thus are typically cold or cool during summer. These streams support coldwater communities that include naturally-reproducing and stocked trout species. The remaining streams and rivers are warmer and support diverse aquatic communities, populated by a variety of minnow (*Cyprinid*), sucker (*Catastomid*), perch (*Percid*), and sunfish (*Centrarchid*) species. Streams that connect to the Great Lakes also provide seasonal spawning and rearing habitats for a variety of abundant, migratory Great Lakes fishes; these are typically fishes that prefer cold or cool water temperatures.

Fisheries habitats are categorized according to their unique features and roles that they play in the life cycle of fishes. Several categories of aquatic habitats have been identified in Eagle et al. 2005 and include: shoreline, nearshore, and offshore areas, ponds, lakes (small, medium, and large), headwaters and small tributaries (cold and cool), medium rivers (cold and cool), large rivers (cold and cool), very large rivers, bogs, fens, wetlands (ephemeral and emergent), swamps, and floodplains. Unique attributes can also be associated with each of the major habitat types such as nutrient status and dominant substrate. Each of these features and their status has been categorized by Great Lakes basin as part of the State Wildlife Action Planning efforts (Eagle et al. 2005).

Conservation needs related to aquatic habitat include addressing issues of invasive species and fragmentation of habitats. Displacement of native species populations by invasive species results in altered food webs, changes in nutrient dynamics, disruption of natural processes, and alterations in life cycles of the native species (Eagle et al. 1995). Habitat fragmentation is caused by changes in land use or by barriers to fish passage. This can be disruptive to both migratory species such as salmon and walleye as well as non-migratory species such as brook trout or smallmouth bass as fish are known to use multiple types of habitats and areas throughout their life cycles. Other habitat issues related to aquatic resources include the conversion of wetlands to other types of land use, dredging of near-shore areas, channelization, alterations to riparian zones, dams, erosion and altered sediment loads in streams, altered hydrologic regimes, and disease (Eagle et al. 2005).

As mentioned in the previous section, the Great Lakes waterways experienced an extremely high rate of invasive species introduction and establishment after the Welland Canal was opened, and from the ballast water of ocean-going ships. In addition to alewife and sea lamprey, several other ecologically disruptive introduced species include round goby, the zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), and spiny water flea (*Bythotrephes cederstroemi*), and the fishhook water flea (*Cercopagis pengoi*) have caused abrupt declines in economically important or rare species, massive changes in food webs, and considerable economic costs. Although PCB levels appear to be dropping in fish found in the Great Lakes, the bio-accumulation of methyl-mercury and PCBs continues to be of concern in the State. The Michigan Department of Community Health has issued a special advisory for all inland lakes in Michigan due to mercury levels in predatory fishes such as pike and smallmouth bass.

3.5 - Socioeconomic Context - Human Uses and Trends

Michigan's forests are a significant component of the social, economic and environmental well-being of its citizens. The economic contribution of these forests include employment opportunities, wealth creation and the production of commodity and non-commodity products and values for the benefit of both the rural and urban population of the state. Wood products and forest-based recreation and tourism are the two primary elements of the overall forest-based economy, and both elements are beneficial for the development and maintenance of strong rural economies. During 2005, these two combined sectors are estimated to provide 150,000 jobs and contribute over $10 billion to the state economy. They form the economic backbone of much of the rural northern two-thirds of Michigan.

State Forest lands provide for a wide variety of human uses, including production of timber and fiber for the forest products industry, oil, gas and mineral production, hunting and fishing opportunities, recreation and tourism, and public education and research. Sustainable forest management is greatly influenced by the demands of each of these uses, and shapes the management direction of the State Forest.

3.5.1 Timber Production

Michigan has a relatively diverse timber products economy. This provides a strong economic foundation for the State as well as the means for managing a diverse forest. Three primary industrial categories of timber products are often identified: lumber and wood products, wood furniture and fixtures, and pulp and paper products. All three are well-represented within the State.

In recent decades, these sectors have experienced substantial changes in their markets similar to those affecting agriculture and manufacturing. Such changes have included new technologies and their accompanying costs, globalization impacts, and organizational restructuring. Despite the changes, the timber products industry remain vital to the economic wellbeing of Michigan communities and will continue to be so for decades to come.

Besides the jobs they directly create, they are also responsible for many jobs and income in trade and transportation sectors, as well as additional indirect jobs from their economic activity. In total, Michigan's timber products industry and related service and support sectors are estimated to sustain over 100,000 jobs and provide close to $8 billion of value added to the statewide economy.

The lumber and wood products category includes sawmills, manufactured product mills (oriented strand board, etc.), millwork, and wood containers (pallets, etc.). Including logging, this category has close to 2000 businesses employing close to 15,000 people. Annual salaries exceed $400 million, and the value added to the state economy that is directly attributable to this category approaches $1 billion.

Michigan's office furniture industry is prominent on a global scale, employing more than 30,000 people with a payroll in excess of $1 billion. This industry's roots can be traced back to an earlier logging era. Today, there remain close to 10,000 people engaged in wood furniture and fixtures manufacturing.

Michigan has close to 200 pulp and paper establishments, producing a wide variety of products ranging from printing and writing paper, envelopes, paperboard containers and an assortment of other products. These companies employ over 16,000 people, with a payroll in excess of $700 million, and contributed over $2 billion (value added) to the state economy.

Michigan's timber industry is inextricably linked to both domestic and global markets, which has tremendous implications for the well-being of this sector of the state economy, and for the strength of many rural economies throughout the northern regions of the state. Although the state has a diverse timber products economy, it is a net importer of wood-based products, ranging from lumber, composite panel products, and veneer, through household and business furnishings, and paper products The annual demand for wood-based products is roughly equivalent to annual tree growth in all of the state's forests. As of 2003, however, annual growth exceeded annual harvest by a ratio of 1.7 to 1 (Table 5). Excess demand is thereby being met by imports from other domestic, and increasingly global, markets.

World-wide demand for wood products has continued to rise in recent years, reflecting growing economies both domestically and internationally. Domestically, the housing industry has been a primary driver of an increased demand for materials used in new home construction. Recent devastating hurricanes in the Gulf region of the United States should maintain increased housing industry demands for wood products for some years to come. Internationally, much attention has been paid to new large wood product demands coming from China.

There are several factors that have a complex but direct bearing upon demand in both domestic and international markets. These are an increasing demand for wood

products that are internationally certified for production in a sustainable manner; greater efficiency and scale of timber and fiber production (including climatic factors and land and labor costs), federal tax policies; international trade agreements; and increasingly higher transportation costs. These factors have impacts upon the operation and profitability of both primary and secondary producers of forest products in Michigan and the Great Lakes region, which are reflected in recent shifts in corporate ownership, land ownership patterns and employment. Local or niche markets, which in large part are driven by transportation costs, may play an increasing role in the profitability of both primary and secondary producers of timber product in the state. Moreover, the state's large positive growth balance in timber relative to other states may lead to additional expansion of its timber products economy.

3.5.2 Oil, Gas and Mineral Production

Part 5, Section 502, of the Natural Resources and Environmental and Protection Act (NREPA),1994 PA 451, as amended, authorizes the Department of Natural Resources (Department) to enter into contracts for the Metallic and Nonmetallic Mineral, Oil and Gas and Underground Gas Storage Leasing Programs.

At the end of FY 2005, there were 48,647 acres under 203 State Metallic Minerals Leases resulting in revenue totaling $168,668, which was related to bonus and rentals. Mining for metals in Michigan in FY 2005 resulted in the production of iron ore along with a very small amount of copper and silver, all on private lands. Today, exploration efforts continue on the State-owned lands under lease, while applications for new leases are being received on a regular basis.

At the end of FY 2005, there were 3,226 acres under 38 State Nonmetallic Minerals Leases, which resulted in $334,733 total revenue all from royalty payments. Special Leases were developed for Construction Sand, Gravel, Cobbles, Boulders, and Clay as well as one for Limestone or Dolomite. The production of nonmetallic minerals from State-owned land continues to be an important source of locally utilized materials for road and other construction purposes.

At the end of FY 2005, there were 785,114 acres under 7374 State Oil and Gas Leases resulting in total revenue of $73,182,040, of which $62,220,262 was related to royalty. The December 2004 Oil and Gas Auction resulted in 96,764 acres being leased and the June 2005 Auction resulted in 70,845 acres being leased, for combined total revenues of over $10 million. By the end of FY 2005, the price of oil reached $56 per barrel and gas reached $9 per Mcf.

At the end of FY 2005, there were 31,412 acres under 78 State Underground Gas Storage (UGS) Leases, which resulted in $73,468 in revenue. Sixteen leases totaling 18,446 acres do not have an annual rental, as all monies were paid in advance for the longer-term leases. Several Northern Niagaran Reef Trend oil and gas fields have been converted to UGS Fields. These fields, with the recycling of natural gas, produce additional liquid hydrocarbons, that otherwise would not be recovered.

Revenue received in FY 2005 for all four programs was the second highest in the DNR's mineral leasing history, which dates back to 1927. Given the current global conditions, FY 2006 mineral activity on State-owned lands, and the related revenues, is expected to remain high.

Since 1976, annual revenues from the development of State-owned mineral resources, largely oil and gas, continue to provide revenue to the Michigan Natural Resources Trust Fund (MNRTF), which provides financial assistance to local governments and the DNR for the purchase of lands for outdoor recreation and/or the protection of natural resources and open space. The MNRTF also assists in the appropriate development of land for public outdoor recreation. However by law, no more than 25 percent of the Trust Fund revenues available for appropriation each year can be used for development, therefore the majority of funding is allocated for acquisition projects.

3.5.3 Forest Recreation and Tourism

Michigan has the largest public land base for dispersed recreation east of the Mississippi River. Direct and secondary benefits from tourism and recreation in the state are estimated to have contributed around $16 billion to the state economy in the year 2000. Of this total, $3 billion was spent on outdoor recreation which supported approximately 50,000 jobs throughout the state. The State Forest contributes greatly to overall state recreation and tourism opportunities. In 2000 there were 3.6 million visits to developed State Forest recreation and trail facilities, totaling 22.2 million annual hours of recreation. There were an additional 9 million visits for dispersed recreation upon the State Forest totaling 23.5 million annual hours.
Selected economic impacts of recreation and trail programs in the Forest, Mineral and Fire Management Division have significant economic impacts for Michigan's local communities. Spending on overnight trips of greater than 100 miles from home generates $110 million in spending. Recreation equipment sales spending is $235 million. This supports 6,455 Michigan jobs.

Traditional recreation and tourism activities such as camping, hunting, fishing, hiking and biking were focused primarily during summer and fall months. As the popularity has increased for many winter sports such as snowmobiling, skiing and ice fishing, forest recreation is now trending toward year-round use activity. This diversified activity provides year-round benefits to many local economies that were previously more seasonal in nature.

The State Forest comprises 47 % of Michigan's public land base. This large public hunting ground contributes significantly to the 8.9 million hunter days, enjoyed by 705,000 residents and 49,000 non-resident hunters. In 2001, the overall value of hunting to Michigan's economy was estimated at 1.3 billion dollars, including: 670 million in retail sales, 326 million in wages and salaries, 103 million in tax revenues, and 12,144 jobs (IAFWA 2002). White-tailed deer hunting is the most popular game species hunted in Michigan and accounted for 506 million of the 1.3 billion dollars of economic activity associated with hunting in Michigan in 2001 (USDI and USDC 2001).

The State Forest recreation program consists of an integrated system that includes developed facilities for camping, pathways for multipurpose motorized and non-motorized (hiking, skiing, biking, snowmobile, Off-Road Vehicle (ORV) and equestrian) trail recreation, and developed water access sites for boating and fishing, as well as undeveloped and dispersed recreational opportunities such as hunting, food gathering and wildlife viewing. In developing, operating, maintaining and promoting this recreation system, the DNR focuses on balancing the impacts these uses have upon the integrity of the whole forest system.

The state forest campground program was started in 1926 in response to increased unregulated camping in state forests. This use was jeopardizing the continued health and well being of the forest by increasing the risk of forest fires and causing user generated soil erosion problems. From its inception, state forest campgrounds focused on providing rustic camping opportunities with limited amenities, no programming, small campgrounds and large waterside sites. The forest is the main attraction of a state forest campground. In 2000, there were 149 campgrounds with 3,383 sites. All 149 are located on a lake or stream. Ninety have developed water access sites to facilitate boating and all 149 offer on-site fishing opportunities. Eleven are horse trail camps, attached to the Michigan Shore-to-Shore Riding Hiking Trail. Sixty one provide direct access to state forest pathways (non-motorized state forest trails) and seven have direct access to the ORV trail/route system.

Developed water access sites to facilitate boating and fishing are maintained at 116 locations, 90 of which adjoin campgrounds. These sites include parking and a ramp to launch boats, and can include toilets. These primarily provide access for fishing and small water craft. Additional access is provided via forest road endings or crossings on the 7,500 miles of rivers and streams in the state forest system. These include much of the blue ribbon trout fishing opportunity in Michigan on streams such as the AuSable, Manistee, Jordan, Pine, Pere Marquette, Sturgeon, Maple, Thunder Bay and Escanaba Rivers.

Extensive aquatic resources throughout the forests provide tremendous recreational opportunities to the large human population of Michigan and nearby states and provinces. Recreational and commercial fishing are known to be extremely valuable: approximately 1.4 million Michigan residents and 352,000 non-residents angled in Michigan in 2001. They fished over 19.3 million angler days, worth a conservative direct economic net value of $839 million. The overall value of this angling was estimated at $2.1 billion in retail sales, wages, tax revenues, and jobs. In 2001, Michigan ranked seventh nationally in economic value of recreational fishing. Commercial fishing in Michigan's Great Lakes waters produced an annual total value of $16.3 million.About 2/3 of Michigan's recreational angling occurs on inland waters. Walleye are sought by many anglers and occur in many of the northern lakes larger than 300 acres. There are good fisheries for lake trout and rainbow trout in several of the large, deep, oligotrophic lakes. Other gamefish targeted by lake anglers include smallmouth bass, largemouth bass, northern pike, muskellunge, and panfishes. Trout angling is avidly pursued on northern streams, with angling for walleye, northern pike, and smallmouth bass in the larger, cooler rivers. Major fisheries for Great Lakes fishes occur where rivers connect to the big lakes. Species targeted on northern rivers include Chinook and coho salmon, steelhead (rainbow trout), walleye, smallmouth bass, white and longnose sucker, and northern pike.

The dispersed recreation opportunities provided by the state forests are exceptional, providing extensive areas for hunting, mushroom and berry picking, nature observation and dispersed camping. The state forests are a key reason why Michigan ranks nationally at or near the top, in hunting and fishing participation each year. The state forests provide fourteen times more public hunting area than the game area system on a statewide basis. This can potentially act to relieve crowding in Michigan's game areas and state parks that are open to hunting, and provides a vast array of public hunting options. The forests provide the public access, quality habitat and clean watersheds to sustain these activities.

Non-motorized pathway/trails (multi-purpose recreational) provide an opportunity for hiking, bicycling, equestrian use, cross-country skiing and nature observation. They range in length from less than one quarter of a mile hikes, to scenic overlooks, to pathways hundreds of miles long. There are 66 state forest pathways stretching a total of 880 miles. More than one-quarter (242) of pathway miles are groomed to support cross-country skiing, receiving extensive use by local residents and tourists. Over a third of the miles are in the Michigan Shore-to-Shore Riding Hiking trail, which stretches from Oscoda to Empire and involves the cooperation of the Michigan Department of Natural Resources, the US Forest Service, the Michigan Trail Riders Association, equestrian associations, utilities, private land owners and local units of government. Another notable trail program is the 145 certified miles of the National Park Service North Country Scenic Trail, portions of which are located on Michigan state forests.

The Trailways Program capitalizes on the infrastructure of inactive railroad rights-of-way which often provides a statewide connection from town to town, utilizing the rail bed and existing bridge structures for the trail. As active rail lines become inactive, these corridors present a one-time, limited window of opportunity to link communities, resources, culture and people. Much of the direction of the program is outlined in the *1993 Michigan Statewide Trails Initiative.* Rail-Trail mileage in Michigan has grown from the first miles acquired in 1970 in the Upper Peninsula to a system approaching 1,200 miles. In 2006, there are 1,145 miles of Rail-Trails in Michigan, with 814 miles (71%) managed by Forest, Mineral and Fire Management, 198 miles by Parks and Recreation Bureau and 163 miles by local units of government. For the period of 2000 to 2005 there have been 300,000 annual visits to these trails.

The ORV Trail program provides four types of trail riding opportunities; motorcycle trails, all-terrain vehicle (ATV) trails, ORV routes and scramble areas. There are 5 scramble areas, 2 of which are in state forests, St. Helen's Motorsport Area and Black Lake Scramble Area. The ORV trail/route system currently covers 3,193 miles with 73% located in state forests. 40% of the system is dedicated to cycle trails, 43% to ATV trails and 17% to ORV routes. In the Lower Peninsula, the system is the only legal place to ride Non-Secretary of State licensed ORVs on public lands other than frozen waters. In the Upper Peninsula, it is legal for ORVs to operate on state forest roads as well as the designated trail system, unless a specific state forest road is posted closed to ORV use. There were 4.2 million annual use days in the period of 1998-1999. The number of ORV licenses has increased by 77% since 1998 to a 2004 total of almost 186,000.

There were 6,216 miles of designated and groomed snowmobile trails in 2005, with approximately 25% of the designated trails on state forest lands. Both snowmobile and ORV trail systems rely upon the cooperative working relationship of the DNR with 65 non-profit groups and local units of government to perform trail maintenance and grooming activities, which are supported by user fees. 78% of all snowmobile use is on the designated trail system, of which 82% is by state residents and 18% is by our-of-state visitors. Snowmobile trail permits peaked in 2001 at almost 270,000 permits, and have declined slightly with a 2002-2005 average of 250,000 permits per year due to lower seasonal snowfall.

3.5.4 Public Research and Education

The Michigan Department of Natural Resources budgets approximately $8 million per year to support a wide variety of on-going forestry, wildlife and fisheries research projects that are designed to increase knowledge and to improve methods of sustainable management of Michigan's public lands. Many of these research projects are accomplished in cooperation with State Universities through formal agreements (Partnership for Ecosystem Research and Management (PERM)) and on an as needed call for proposals for subjects of interest. The DNR produces an annual report to document the commitment to sustainable forestry research and to inform discussion on research needs and collaboration opportunities among the DNR Divisions.

Products of research projects often include educational materials that serve to convey research findings to the public. Since almost 63% of timberland in the state is in private ownership (Figure 2.4), public education programs are a critical part of encouraging sustainable natural resource management throughout the state.

4 - STATEWIDE MANAGEMENT DIRECTION

4.1 – Desired Future Conditions, Goals, Objectives, Standards and Guidelines

This section contains specific statements of the desired future condition of the State Forest, and the goals and objectives through which the DNR's long-term management objectives (as outlined in Section 1) can be achieved. The Department has a vision of the desired future conditions of DNR-managed forest lands, which is predicated upon a sustainable, ecosystem-based management philosophy. When achieved, the desired future conditions will:

1. Sustain fundamental ecological processes and functions that, in turn, support representative, diverse, and productive biological assemblages that provide a wide array of resource outputs.

2. Provide for a variety of ecosystem services that help sustain human civilization. Examples include purification of air and water, carbon storage, and moderation of drought and flood conditions.

3. Provide for a variety of sustainable human values that are derived from ecosystems; including economic, recreational, and intrinsic values.

4. Provide for a variety of forest-based products.

Standards and guidelines are included as tools for DNR staff to use in the achievement of these goals through the operational management of the State Forest. Where standards originate from higher authority, they retain higher precedence than the contents of this plan. Monitoring criteria are provided as a tool for assessing progress toward the achievement of goals, objectives and desired future conditions.

As previous discussed at the beginning of Section 3, there are many competing demands for human use of the State's forest resources, and provision of one use is always constrained by demands for other competing uses for the same resource. The desired future conditions, goals and objectives that are laid out in the following sections for the many